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ABSTRACT

Map and compass skills are a neglected aspect of the elementary school curriculum. Orienteering--a sport that involves running a prescribed course with the aid of map and compass--may provide an avenue for teaching these skills. This study taught orienteering to 148 10-year-old children and compared the effectiveness of a serial approach based on step-by-step rule-based learning, with that of a conceptual approach focused on understanding the relationships between relevant concepts. Prior to training, all subjects passed a screening test of the ability to read a simplified map and follow right, left, and forward directions; there were no significant differences by sex or handedness. Eight teachers were trained in the serial and conceptual approaches and then used one of these approaches to teach their students for 2 months, approximately 2 hours per week. The teaching package covered elementary navigation, map drawing and use, orientation with and without compass, and bearings work. The conceptual approach included the concept of rotation from the north, articulated either as cardinal points or a precise numerical bearing. On a series of six progressively harder post-tests (both indoor and outdoor), conceptual approach subjects performed significantly better than serial approach subjects; there were few differences between boys and girls. Relationships between orienteering skills and attainment targets of the National Curriculum in Geography and Mathematics are discussed. (SV)

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Sports Science Education Programme

ANNUAL REPORT 1989/90

Developing Navigational Skills with Young Children: Investigating serial and conceptual approaches to the teaching of compass skills

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SPORTS SCIENCE EDUCATION PROGRAMME

A N N U A L R E P O R T

DEVELOPING NAVIGATIONAL SKILLS WITH YOUNG CHILDREN:

Investigating serial and conceptual
approaches to the teaching
of compass skills

University of Liverpool/British Orienteering Federation

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ANNUAL REPORT : No 1

DEVELOPING NAVIGATIONAL SKILLS WITH YOUNG CHILDREN: Investigating serial and conceptual approaches to the teaching of compass skills

1 Individuals involved in the project

Research Director	J R Martland,DASE, MEd, MRIN
Research Assistant (Part-time 0.5)	S Walsh, MPhil
Consultant Psychologist	R R Stewart, MA
Secretary	D Jennings

The project is guided by a steering committee which comprises three representatives from the British Orienteering Federation, three members of University Departments of Education and three inspectors/advisers from Wirral LEA.

Steering Committee:

W E Marsden (chair)	Reader in Geographical Education - Liverpool University
M Schilling	Centre for Research in Science and Technology - Liverpool University
D Boardman	University of Birmingham
P Palmer	Director of Coaching, BOF
T Renfrew	Coaching Committee Chairman 1989-90, BOF
C McNeill, OBE	Senior Coach, BOF
R Markham	Senior Inspector, Wirral LEA
H Blair	Senior Inspector, Wirral LEA
G Morris	Advisory Teacher, Wirral LEA

2 **Budget Statement 1989-90**

(1) Statement of expenditure and income for the period 1 November, 1989 - 31 August, 1990. 7

(2) Position of Research Grant 1 October, 1990. 8

(3) Position of Research Grant 19 October, 1990. 10

THE UNIVERSITY OF LIVERPOOL

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Sarah Rowell
The National Coaching Foundation
Sports Council
16 Upper Woburn Place
London WC1H OQP

Please Quote: Tax Point

No 491039 21 August 19 90

S. Bowles/LMC

Payment is requested of the amount now due from you as shown below. Cheques should be made payable to The University of Liverpool

Developing Navigational Skills with Young Children : Investigating Teaching Approaches and Compass Types

Statement of expenditure and income for the period 1 November 1989 - 31 August 1990

	£	£	£
Cash received			12,305.00
Expenditure			
Staff Costs			
S. E. Walsh @ £5,868 p.a.	4,148.60		
National Insurance	286.04	4,434.64	
D. Jennings @ £3,160 p.a. (Part Time)	2,030.15		
N ational Insurance	65.88	2,096.03	
Stores etc.		1,408.03	
Travel		1,087.88	
Overheads		1,244.00	10,270.58
			£2,034.42

.....
%Assistant Director of Finance

MR J R MARTLAND
EDUCATION
(RENEWED ANNUALLY)

FROM: THE DIRECTOR OF FINANCE

RESEARCH GRANT ACCOUNT NO. 491039

ON ALL GRANTS IN OPERATION PRIOR TO 1ST AUGUST 1986 THE AMOUNTS SHOWN IN THE FIRST COLUMN REPRESENT THE AMOUNTS AVAILABLE AT THAT DATE.

THE POSITION OF YOUR RESEARCH GRANT FROM SPORTS COUNCIL

AS AT 04/10/90 IS GIVEN BELOW

	GRANT	EXPENDED	BALANCE UNSPENT
	£	£	£
CONSUMABLE STORES & OTHER COSTS	1470.00	1408.03	61.97
SALARIES (TECHNICAL & CLERICAL)	2415.00	2263.39	151.61
SALARIES (ACADEMIC & ANALOGOUS)	5876.00	5206.66	669.34
TRAVEL AND SUBSISTENCE	900.00	1157.88	257.88-
EQUIPMENT - NON-INVENTORY	400.00	0.00	400.00) £390 Transferred to Travel 16/10/90
	£ 11061.00	£ 10035.96	£ 1025.04

ACCORDING TO OUR RECORDS THE PRESENT CONTRACT IS DUE TO EXPIRE ON 31/08/91

.....

11

DIRECTOR OF FINANCE

12

THE UNIVERSITY OF LIVERPOOL

MONTHLY RESEARCH INCOME & EXPENDITURE STATEMENT

THIS TABULATION IS AN ANALYSIS OF THE UNDERMENTIONED ACCOUNT DURING THE PERIOD STATED AND IT SHOULD BE CAREFULLY FILED. ANY QUERIES ARISING FROM THIS STATEMENT SHOULD BE ADDRESSED TO THE DIRECTOR OF FINANCE.

ACCOUNT NO.	MONTH	YEAR	SHEET
491039	AUGUST	1990	1
	SEPTEMBER	1990	

MR J R MARTLAND
EDUCATION
(RENEWED ANNUALLY)

SPORTS COUNCIL

DATE	ORDER	VOUCHER	NARRATIVE		DEBIT	CREDIT	OUTSTANDING ORDERS	
						2833.81		
			OPENING BALANCE			2888.70	95	
27/09/90		90361J	SPORTS COUNCIL				08	
28/09/90		99999J	GROSS CHARGE PAYROLL TYPE MP ✓		344.12		07	
28/09/90		99999J	GROSS CHARGE PAYROLL TYPE MP ✓		570.38		08	
28/08/90		99999J	GROSS CHARGE PAYROLL TYPE MP ✓		99.33		07	
28/08/90		99999J	GROSS CHARGE PAYROLL TYPE MP ✓		724.94		05	
21/08/90	341264	90351	✓G B COACHES	1488	40.00		05	
19/09/90	341266	91689	✓AL'S MINI COACHES	0847	30.00			
						3913.74	0.00	
							3913.74	REMAINS

13

14

UNIVERSITY OF LIVERPOOL

Research Grant Account No. 491039

Position of Research Grant as at 19 October 1990

	£
Unspent balance: ..	1025.04
Expended:	
Travel	307.06
Consumables ..	62.35
	566.63

3 Progression of the project in relation to the stated aims

3.1 The aims of the project are

i) To examine the ability of children, aged 10+ years, to acquire, and use, two key skills in orienteering and navigation, namely map orientation and direction finding using a protractor compass.

ii) To evaluate two differing teaching approaches in equipping the children to establish direction and solve navigational problems using a protractor compass. The approaches are termed serial and conceptual.

iii) To explore the teaching/coaching problems entailed in the progression from a serial approach to the conceptual approach and vice versa.

iv) To identify the similarities and differences in the performance of boys and girls in solving a series of navigational problems and to examine the implications of any such differences for coaching.

v) To examine the differences in performance overall in directional skills in both simulated and natural environments.

vi) To establish the range and scale of the accuracy of response and the speed of response in the solution of a variety of navigational problems ranging from the simple to the relatively complex.

The report which follows shows that all aims were attempted, though number (iii) was seen as unrealistic given the time constraints. The principal focus centres on aims (i) and (ii) and the results are discussed in relation to aims (iv) to (vi). The qualitative analysis of the teaching programme and the empirical results allow statements to be made regarding aim (iii) but the cross over design, originally intended was not conducted.

3.2 The Task

The purpose of this study is to examine the comparative effectiveness of two approaches to the teaching of key compass skills in the sport of orienteering. The two approaches are termed serial and conceptual. The serial approach describes a step by step rule-based method based on instrumental, or habit learning whereas the conceptual

approach refers to understanding the relationships between the concepts involved. It is envisaged that the learner will be equipped with an understanding of not only what to do to complete the skills but also what is involved and why the task is completed.

The research is conducted with 148 children aged 10 and 11 years and the particular items examined are the basic skills of orienteering and include using the compass to orientate oneself and a map, taking bearings of features in the terrain and from maps, and the establishment of location both on maps and within the terrain.

3.3 Why is this problem important?

The justifications for this study lie in five main areas. These are outlined below and then set out in greater detail.

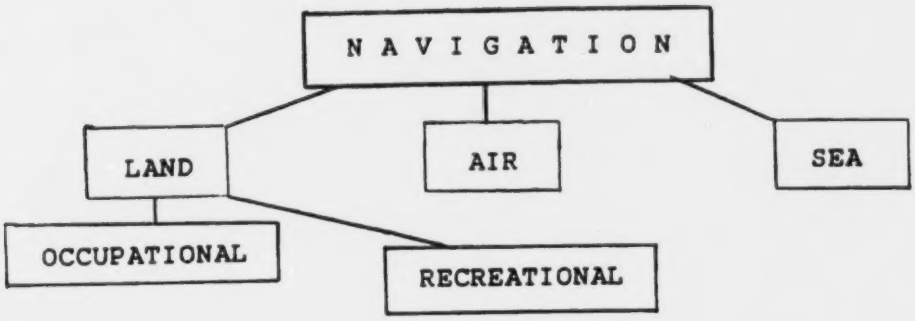
First, there is little evidence of research into the use of compasses as aids to navigation with children of primary school age.

Second, recent developments in compass design in the past decade have provided a range of compasses for educational and recreational use. There is a need, therefore, to ascertain what primary pupils can do, and have difficulty with, when using compasses.

Thirdly, the approach to teaching how to use compasses promoted and perpetuated in the literature follows a rule based method leading to a solution. Alternatives to such an approach have not been attempted. The weakness of a rule based approach is that new sets of rules have to be learned to be applied to new problems. This study sets out to examine the efficacy of a conceptual approach which it is hypothesised equips the learner to apply existing knowledge and understanding to new problems.

Fourthly, research shows that the performance of girls in tests of spatial skills falls behind that of boys from the age of eight years and that the gap grows progressively with age. The study wishes to ascertain whether this applies to directional skills employing compasses.

Finally, the national curriculum sets the attainment targets for the teaching of cardinal points, bearings, and direction including angles at different levels in the geography and mathematics curriculum. It is hoped that this study may shed further light on the relationship of the attainment levels and children's competence.



environmental pursuits

expeditions

fell walking

fell running

ORIENTEERING

outdoor pursuits

mountain marathons

guiding

rambling

scouting

wayfinding

Fig. 1 The relationship of the sport of orienteering to the concept of navigation

To sum, the compass, with the map, are the key tools in the sport of orienteering. By examining an alternative approach to teaching the compass skills it is hoped that orienteering coaches will be informed of the competencies and problems which primary children bring to the sport and also to be aware of the progression and sequence in teaching approaches for compass use. By relating the sports study to educational issues, both in the national curriculum, and to gender, it is hoped to provide evidence which will enhance sport pedagogy in general and orienteering, recreational pursuits and primary education in particular.

Each of the five main justifications are set out below in more detail.

3.4 Research on the compass as an aid to navigation with the young

Birds, insects, fish, animals and humans encounter three problems when they navigate. These problems can be illustrated by three simple questions. These are "Where am I?", "Where am I going?" and "How do I get from where I am to where I want to be?" The problems are solved using reference systems involving the senses, the direction of sun or stars, the earth's magnetic field or inertial systems. Each of the above can be used by man but only man can employ artificial means to aid navigation. Navigators rely on compasses, radio bearings, distance measuring equipment, global positioning satellites and maps, including digital maps. These artificial devices are for essentially commercial and practical use but are also used in recreational pursuits, for example, the protractor compass is an essential tool in orienteering.

Orienteering is a running sport in which the competitor navigates with the aid of a map and a compass to find a fixed number of control points which are indicated on the map and marked in the terrain by red and white control markers. At the elite level it is an extremely physical and mentally demanding international sport but it also provides leisurely, outdoor activity for individuals and groups aged from eight to eighty and beyond. Orienteering takes place in parkland, forests, fellsides and on moorland. Its appeal is in the sense of accomplishment of being able to navigate at speed in unknown terrains. Irwin states that the ability to solve complex navigational problems perhaps demonstrates more elegantly than any other skill an individual's intellectual mastery of his environment. The relationship of the sport of orienteering to the concept of navigation is set out in Fig. 1.

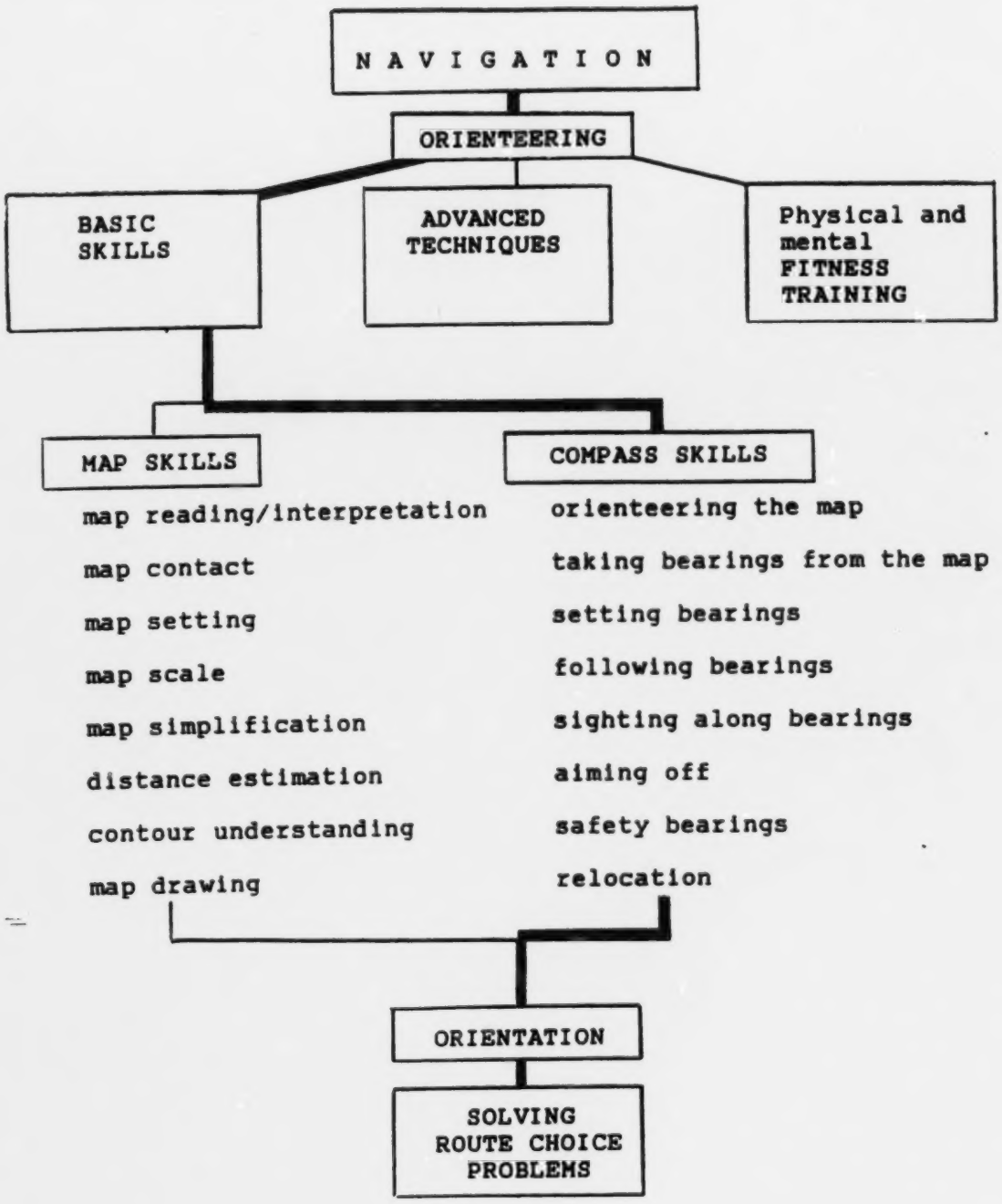


Fig. 2 The basic skills of orienteering

There is already a considerable literature on children's acquisition of map reading and interpretative skills. These include the understanding of map symbols, their colour and legibility, the use of models and aerial photographs, scale, contours and grid co-ordinate systems. There is also a wealth of literature on children's cognitive maps, orientation and spatial concepts.

More recently, developmental psychologists have investigated route planning, wayfinding, locating objects in space and using elementary maps to follow routes. The majority of this work has concentrated on children of pre-school age (0-4 years) and has been conducted in small scale environments in which all features are visible from one vantage point.

There appears to be little research on the use of compasses as aids to navigation with children of primary age and none that we are aware of that examines the key skills of orientation of maps, taking bearings and applying this knowledge to locational and relocational problems.

Figure 2 illustrates the map and compass skills of orienteering as an aid to identifying the centrality of the area of research.

3.5 Developments in compass design

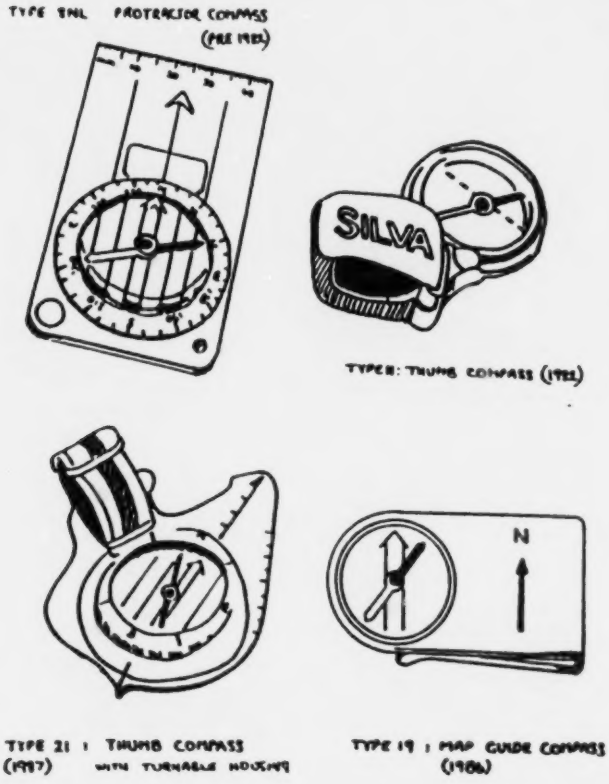
There are currently 47 types of compass on the British market of which 13 are intended for use by walkers, ramblers, schools, scouts, guides, orienteers, fell runners and adventure groups.

These 13 can be subdivided into three groups, namely the protractor compass, the thumb compass and the map guide compass. These are illustrated in Fig. 3.

Each compass contains a magnetic needle, pivoted on a sapphire bearing, mounted in a fluid filled, clear plastic housing. This allows the needle to settle quickly, ie. within 4 seconds from a deflection of 90° at 20° Centigrade.

The three types differ in their use and appearance. The most commonly used, and the one studied in this research, is the protractor compass which has the compass housing mounted on a clear, acrylic baseplate, which is engraved with lines and scales. The compass housing rotates through 360 degrees and the protractor markings indicate the four cardinal points and every second degree. Some protractor compasses also contain a magnifying lens and scale bars.

Fig. 3 Compass designs



The thumb compass is intended for competitive orienteers and has a large, strong magnetic needle in a non-rotating compass housing. It is positioned on the thumb, hence its name, and allows the map and compass to be employed as a single unit.

In 1989 a thumb compass with a rotatable compass housing was developed to give the advantages of the thumb compass combined with the protractor compass. Essentially thumb compasses are for use with advanced and elite orienteers.

The map guide compass, however, is aimed at the young beginning navigator. It is a precision instrument having the same sapphire bearing pivot for the magnetic needle. This is housed in a clear non-rotating capsule which is coupled with a base plate shaped as a clip so that it can be attached to the map. It has the advantage that it allows the map and the compass to be used as a unit and faciliates orientation of the map. Since the housing does not have a protractor scale it is not suitable for taking accurate bearings.

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Only the protractor compass has the facilities to cover all the necessary compass skills in orienteering, though both the map guide and thumb compasses have a place in the development, and application of, compass skills. This study does use the map guide compass in the early stages of the instruction as a prelude to working with the protractor compass because it has minimal "noise" in the design compared to the protractor compass. The thumb compass is not used.

Since the protractor compass is a complex, precision instrument it is not only necessary to examine the ability of primary pupils to use the instrument but also to establish the place of the simple map guide compass within a teaching programme to enable children to navigate with accuracy.

3.6 Teaching and learning to use a protractor compass: the Serial Approach

A pedagogical examination of the instructional material presented with the protractor compass, be it Scandinavian or Japanese, reveals that the learning is predominantly rule based in that a series of steps are presented which lead to a solution.

A definition of a bearing is given followed by three instructional steps. For example:

> "A bearing is a horizontal angle fixing a direction in respect of North."

Step 1 Place the compass on the map with the edge along the desired line of travel

Step 2 Rotate the capsule until 'N' on the compass dial points to magnetic North on the map

Step 3 Pick up the compass and turn your body until the red end of the needle points to North on the compass dial. The 'direction of travel' arrow in the base now points precisely to your destination.

The steps are illustrated in Figure 4.

The Swedish Silva Compass manufactures refer to this as the Silva system and highlight the simplicity of the three step rules for transferring a bearing from the map to the ground. Essentially, the system is a set of rules to produce a solution. The chain of stimulus response links is small but

Fig. 4 The Silva System

HOW TO FIND YOUR WAY

The Serial Approach

TAKING A MAP BEARING

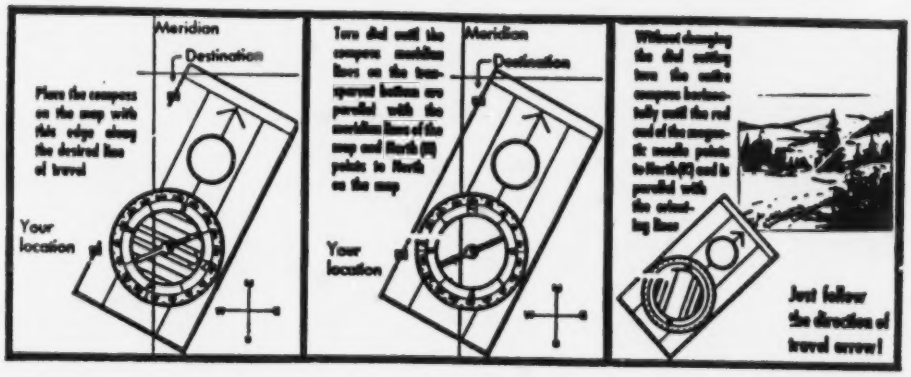
INSTRUCTIONS FOR USE

The instructions given here are intended to acquaint you with some general terms and rules as well as the basic parts and functions of your Silva System Compass.

A **BEARING** is a horizontal angle fixing a direction in respect to North.

THE SILVA SYSTEM — is simple as one, two and three!

The point you want to reach will not always lie exactly on a cardinal or intercardinal direction; it may be anywhere between these directions. Unless you have an accurate bearing, therefore, a small lake or cottage could be difficult to locate. Here your SILVA System Compass — in reality a combination of compass and protractor — is a great help and solves the problem in a very simple way. Just three hand adjustments and the line of travel (the bearing) is transferred from map to compass which then is ready to show you the way. A "flash" lesson in the Silva System is given on these columns.



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each link must be carried out in the correct sequence and timescale. The learning mode for the bearing is thus dependent upon memory and requires each step to be practised. If the steps are not carried out correctly, or in the wrong sequence, or if they are forgotten, then the skill breaks down.

It is proposed by advocates of this approach that the method, or system as Silva call it produces quick and reliable results and that the instruction is both brief and clear, and easy to understand.

However, the teaching of the above method is often handicapped by a lack of an analysis of the constituent items. An examination of the steps of the Silva System will reveal that many of the concepts are not made explicit and recent research shows that the language itself poses difficulties.

Martland (1988) in an study of children's use of the protractor and map guide compass indicates that there are linguistic problem posed for teachers and that children had difficulty in labelling and understanding the three arrows which are present on the compass Baseplate and housing. The orienting arrow in the housing, the direction of travel on the base plate and the north seeking arrow contributed to problems in comprehension and articulation for the instructor and the pupil.

The major criticism of the serial, instrumental approach, however, is that the steps are a fixed route to a particular goal. Should the goal appear in a different guise, or a problem appear that involves the knowledge of bearings for its solution it is possible that the pupil may not recognise it as being solved by the application of the skill he or she possesses.

Teaching and Learning to use the protractor compass:

3.7 The conceptual approach

This study undertook to examine an alternative approach to learning about compass use and bearings which is based in psychological theory related to concept development, hence the label a conceptual approach. A task analysis of the concept of a bearing was seen as an essential part of this approach.

A task analysis not only identifies the elements, or sub-skills, to be learned but also allows the nature of the learning to be established. For example, when the concept of a bearing is analysed key elements such as rotation, clockwise, anticlockwise, degree, angle, and north can be placed in a hierarchy showing which concepts need to be learned as building blocks to higher order concepts. For instance, to understand "bearing" it is necessary to know about "rotation" in a "clockwise direction" from "north." Besides producing the hierarchy of elements analysis of the concept can also reveal how the individual concepts can be taught. For example, rotation, clockwise, and anticlockwise can be taught, though not exclusively, by observation, whereas north, degree and bearings require exemplification and definition. The analysis of the concept of direction expressed as a bearing is shown in Fig 5. The concepts are arranged from simple to complex demonstrating the hierarchy and associated facts, skills and strategies are shown for each level.

Fig. 5 An analysis of the Concept of a bearing

Analysis of the concept of direction (D) = Concepts of definition (O) = Observing and contrasting

Complex ↑ Simple

Concepts	Facts	Skills	Strategies
Bearings (D)	A Reflex angle is greater than a straight angle but less than one rotation	Estimation, Measurement, and construction of bearings	Use of reflex angles
Degrees, Angle, (D) Clockwise, (O) Anti-clockwise (O)	An acute angle is less than 90 degrees	Measurement and construction of angles using circular and semi-circular protractors, Estimation of angles and bearings	Counting the number of right angles. Operate on reminders after ÷ by 4. Relationship of the number of right angles and ¼ right angles
Cardinal Points (D)	NESW		
Rotations, ¼, ½, ¾ Full (O)	Four right angles make one rotation		Construction of models and aids

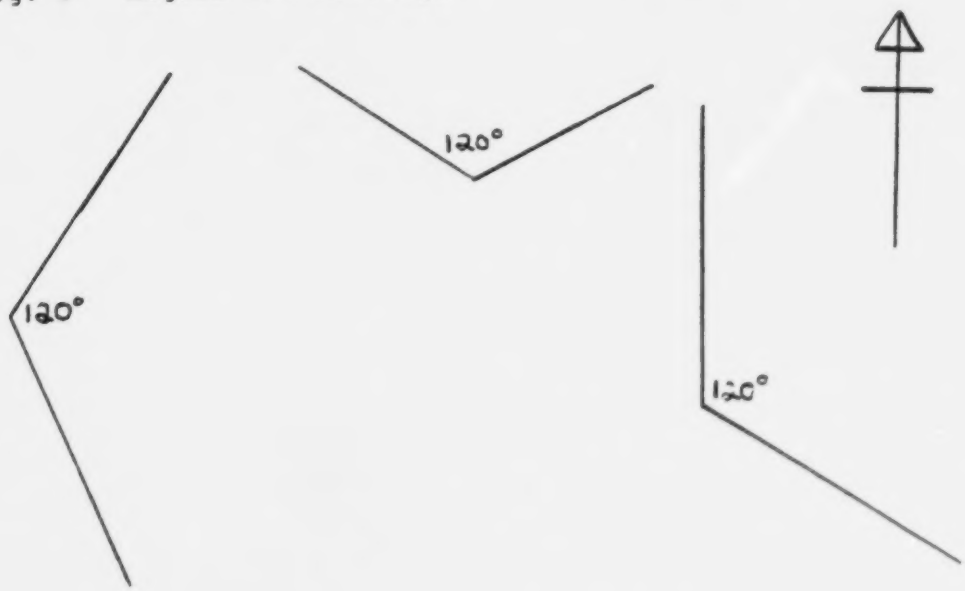
Task analysis, however does not end with identification of the sub-elements of the concept but also leads us to be able to design activities to ascertain whether the learner has the competencies required to enter into the learning. Starting where the learner is, rather than where we assume he/she is, is a key principle in teaching. Therefore, pretest activities which indicated the learner's existing knowledge are central to this approach.

The conceptual approach also draws on the psychological evidence of how concepts are formed and stresses the central role which language plays in concept acquisition.

Concept learning takes place when a common response can be made to a class of stimuli that may differ from each other widely in physical appearance. The learner is able to respond in a single way to a collection of objects as a class. It is dependent upon discrimination learning and

can be tested by asking the learner to select examples of the concept under consideration from non-examples. For instance, a simple illustration to decide whether someone had the concept of a thumb compass would be to ask them to select an example from a range of compasses which included a thumb compass. At a harder level, the concept of bearing is almost similar to the concept of an angle. This is illustrated in Fig. 6 and shows three angles of 120 only one of which is a bearing of 120 degrees. The ability to select the bearing would tend to indicate a knowledge of the concept of a bearing. If the reasons for the choice are then articulated correctly then one has sufficient evidence to conclude that a concept of a bearing is present.

Fig. 6 Angles and bearings



The test of understanding for the concept of a bearing is the ability to select examples from non-examples such as indicated above. Notice it is a practical task. It is not just a verbal test as evidence that the learner can give a definition of the concept does not necessarily imply understanding.

Language does have a crucial role to play in the teaching of concepts however. We have mentioned the role of discrimination, ie. what makes a thing belong to the set of things. The conceptual approach devised for this study places emphasis on the teacher to promote talk amongst the learners, to get them to articulate why the concept belongs or does not belong and, to express their understanding in their own terms and usage.

3.8 But does it matter which approach is used?

The question arises as to whether it matters which approach is used. As already indicated the serial approach places demands upon memory and can be restricted to a limited set of problems. It is hypothesised that conceptual understanding equips the learner with tools to recognise examples of the concept, explain what the concept is, generalize and make inferences and, most importantly, apply the facts and skills learned to new situations and new problems. Because concept learning involved discrimination and classification it makes situations simpler by unifying information thus placing less demands upon memory. It leads also to the ability to produce and devise new plans to complete a task.

It is recognised that the concept development approach will take longer than the serial approach as there is more content to be covered.

3.9 Is one approach better than the other?

The approach adopted by the manufacturers and the instructional guidance to orienteering coaches (Rand and Walker, 72; Smith R, 1982, Thornley J, 1982, and McNeill, Ramsden and Renfrew, 1987) is that of the serial approach. However, in a later book (McNeill, 1989) a diagram does appear alongside the serial information which tends to indicate what the serial process attempts to achieve. It is because an alternative approach to learning has not been attempted that this study is undertaken.

3.10 Gender differences in spatial tasks

There is limited evidence relating to gender differences specific to map and compass use. The abilities of children aged 6 - 11 years both in England and the USA have been examined to recall and draw their home areas including the journey to school as sketch maps.

It was found that from about 8 years on the boys produced maps which were more accurate, more detailed and showed areas further away from their homes than girls. Boys also consistently performed better than girls on contour sketch map tasks obtaining higher scores in relief shading tasks, the identification of slope and the estimation of height.

In general on tests of spatial ability differences are seldom found in children below the age of 8 or 9 years. Between 9 and 12 years where differences between the sexes are found boys score higher than girls. The differences become more pronounced during adolescence with boys showing a clear superiority.

Several conjectures have been put forward why this should be so. There is no direct evidence that there is an innate difference. The lack of confidence in girls in tackling the tasks is suggested. Equally differences in experiences relative to travel within the home area are suggested.

Experiments have been conducted to ascertain whether humans have a separate sense devoted to geographical direction. Work on the ability of adults to judge direction demonstrated that a sense was present. When similar experiments were conducted with children aged 4 years and above the girls were found to be superior to the boys in judging compass direction when blindfolded and that this superiority first appears at the age of 7 - 8 years. Interestingly, the boys first estimates showed significant ability to judge direction with performance over subsequent trials falling away. Girls showed good ability initially which then fell away but was recovered during the latter trials.

Since this research did not ask children to produce maps other than that of their immediate visual environment, that direction would be judged and measured using a compass and not in a blindfolded condition it was hypothesised that no differences would be found in the performance of girls and boys on the six tasks.

3.11 Orienteering and the National Curriculum in Geography and Mathematics

The National Curriculum is expressed as a series of attainment targets, each of which is split into ten levels.

The concepts of direction and angular measurement are indicated in Attainment Target One (AT1) of the Geography Curriculum under the section related to the acquisition of geographical skills to map use and fieldwork. In the Mathematics Curriculum direction is covered by both AT8 (Measurement) and AT11 (Shape and space). By the time a primary pupil reaches 11 years of age the expectation is that the majority will have reached level four of the targets with some pupils progressing to levels 5 or 6.

Fig. 7 shows the statements at each level in the three target areas and these are explained below. The supporting documentation to the curriculum reminds us that direction, distance, scale, area and size are concepts shared with geography and mathematics and that mapwork provides a strong link between the two.

The study of maps is stressed as an important life skill and the reports indicate that pupils should make frequent use of maps in a variety of contexts. For primary pupils this means making, drawing and using large scale maps of immediate and local environments. The guidance to the curriculum points out that the sport of orienteering provides a ready vehicle for practical map use and specifies the skills of orientation, route following, symbol recognition and scale.

How one teaches or achieves these skills, and especially how spatial abilities develop and the role of the compass in that activity is less clear.

For example, in the mathematics curriculum the emphasis is placed on the measurement of angle and its application to geometrical shape. In the geography curriculum the focus is on the understanding of four, then eight cardinal points.

Neither do the examples provided for teachers to illustrate the curriculum help. The notion of rotation, anticlockwise and clockwise turns, and right angles are illustrated via physical education and distance and direction by the use of computer languages and programmable robots. In both curricula greater emphasis seems to be placed on describing position by grid reference than by a polar system. The teaching of bearings to define direction in the field enters

LEVEL	GEOGRAPHY AT1 Geographical Skills	MATHEMATICS AT8 Measurement AT11 Shape & Space
KS1 1	1/1b Follows direction using such terms as front and back, up and down, left and right	11/1a State a position using preposition such as on, inside, above, under etc. 11/1b Give and understand instructions for moving along a line
KS1 2 KS2	1/2d Use NSEW as directions 1/2e Follow a simple route as a given plan	8/2a Use non standard measures 11/2a Understand the notion of angle 11/2b Give and understand instructions for turning through rightangles (PEGym)
KS1 3 KS2 KS3	1/3b Locate their own position on a large - scale map and identify conspicious visible features from the map (orientation) 1/3c Use 8 points of the compass 3/3d Construct a simple map of a short route	8/3b Use appropriate units and instruments in a variety of situations, interpreting numbers on a range of measuring instruments 8/3c Make estimates based on familiar units 11/3b Understand 8 points of the compass; use clockwise and anticlockwise
KS2 4 KS3	1/4d Draw a simple sketch map	11/4a Specify location by means of angle and distance (LOGO)
KS2 5 KS3	1/5d Follow a route on a OS map and by interpreting information on the map describe what can be seen	8/5d Measure and draw angles to the nearest degree
KS3 6	1/6h Use compass bearings to follow a route in the field	11/6a Understand and usebearings to define direction.

Fig. 7 The National Curriculum in Geography and Mathematics related to the teaching of direction

the curriculum at the Secondary Stage (11 to 13 years) at level six of the attainment targets and is illustrated by examples relating to navigation on the sea and in the air, situations which do not have every day relevance for most pupils.

The evidence of protractor compass use in schools is scant and it can be envisaged that directional facts and skills will be learned in abstract using compass roses, weather vanes and the semi-circular protractor in mathematics. Whilst both curricula place great emphasis on the use of the understanding in the application to real problem solving the examination of current primary texts indicates that most skills will be learned in abstract situations.

What then does this mean for the orienteering coach? First, that few primary pupils will have used a protractor compass. Second, whilst possessing the language of direction, such as cardinal points and degrees these will have been gained from two distinct areas and their relationship may not have been drawn. Third, the use of polar co-ordinates for establishing direction will not have been given the same emphasis as grid co-ordinates for point and space location. Fourthly, bearings are not seen as part of the primary curriculum and whilst the pupil may appear to have the language and competencies of directional skills these may not be established or learned by application to solving navigational problems.

Orienteering does provide a practical problem solving activity for learning map and compass skills. The pupil will also gain the skill of using and applying a precision instrument to measure and state direction with accuracy by reading from a numerical scale. This, itself, is a target in the measurement curriculum and whilst we expect primary pupils to use rulers, weighing and timing devices and thermometers, the compass appears to be neglected alongside these.

This research intends to gain empirical evidence to see whether primary pupils can do what is stated, and more. If, for example, they are taught cardinal points, rotation, clockwise, degree, all of which are the components of bearings why is this left to the secondary stage at level six of the National Curriculum?

More fundamentally, can primary children use a protractor compass for orientation, and the measurement and setting of direction? Further can they apply this knowledge to navigational problems including location and identification of features on a map? Can they take and measure bearings

with accuracy and apply this to the terrain to identify a direction of travel? What problems do teaching the facts, skills and understand of direction hold for the primary teacher? Finally, if it is found that pupils can use bearings and the protractor compass what implications does this hold for the coaching programme and course design for young orienteers at M and W 10 and 11 years?

4 An overview of the literature

This brief review of the literature examines map reading skills and map using skills and identifies the work undertaken with preschool, infant and junior children. The work with adults has not been ignored but is not presented here. The research in map reading skills encompasses the concepts of symbolism, grid reference systems, scale, contours and map memory. There is also a large body of work on the use of aerial photographs and cognitive mapping. The research tends to be of an educational nature, principally conducted with upper primary children and is strongly influenced by the Piagetian stance which indicates that young children under 8 - 10 years cannot understand maps nor acquire mapping skills.

New evidence from the developmental and environmental psychologists dispute these findings and their work has concentrated principally on the skills of map use. The central concepts studied include location, direction, orientation, map drawing and route/way finding. The body of research lies much closer to the sport of orienteering. Naturally, the bulk of their work has been conducted with preschool and infant children almost entirely in laboratory and small scale situations. Very little research exists of work in natural environments.

Our project draws on map reading skills but we are predominantly concerned with map using skills especially in exploring the identification of locations, direction and orientation/alignment of maps in both small and large scale environments. It is revealing that the fundamental skills of aligning the map and keeping constant checks on one's position in defining and travelling along routes is neglected in the educational field.

The literature review to date, thus allows us to clearly indicate the important position of our study and we intend to publish articles showing the gap between what children can accomplish in the sport, the National Curriculum guidelines and the educational programmes in school. The benefits one anticipates, are to broaden the base of participants in orienteering by demonstrating the value to educationalists and environmentalists of how mapping skills can be enhanced by the inclusion and application of orienteering skills, games and activities.

5 Statement of Hypotheses relating to compass use in the sport of orienteering

5.1 The place of the compass in orienteering

The map and compass are the essential equipment in orienteering. Most compasses can be used for distance measurement in addition to directional measurement. The research concentrates specifically on directional measurement and how the compass is used to answer the three basic questions of navigation. These are "Where am I," "Where am I going?" and "How do I get from where I am to where I want to be?"

The compass is used to orientate the map, to locate features both in the terrain and on the map, to take bearings and to locate one's position in the terrain. The compass can be used with varying degrees of accuracy depending upon the tactics employed. The above mentioned skills need to be conducted with precision but other skills, such as "aiming off," and "running on the needle," which are used to simplify travel plans, require less accuracy.

Each compass skill is explained in more detail below.

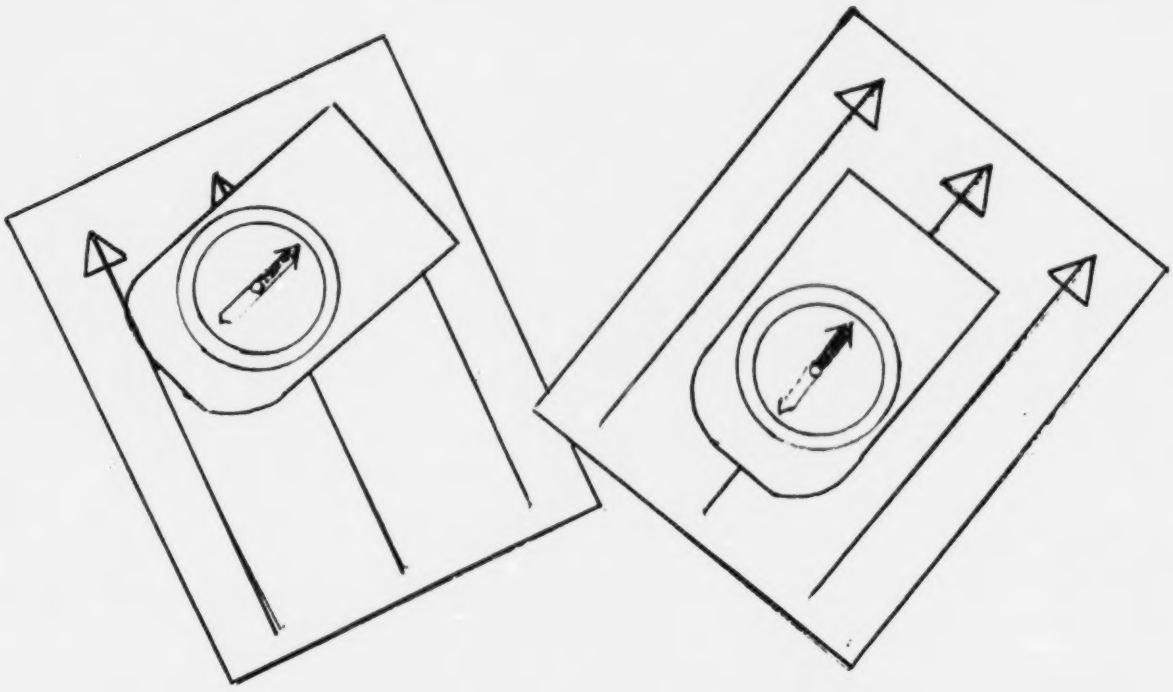
5.2 Orientating the map

Before one can begin to navigate it is necessary to establish one's current location by relating the map to the environment. In simple terms it means "having the map the right way up." If this is achieved then deductions such as "If I'm here, then that must be over there", can be made. If the map is correctly orientated then what is on the left on the map is on the left in the world and vice versa. The direction can also be stated generally or with precision. For example X can be stated to be north west of Y or on a bearing of 315 degrees.

It is relatively easy to make judgements about direction when one is stationary in the actual terrain with the map orientated but much more difficult when the map is not aligned to north. This occurs when the navigator, or orienteer, begins to travel. Orientation of the map and self can be maintained by a continuous updating of one's position relative to reference points by detailed map reading or by the use of the compass. This is achieved by matching magnetic north on the map with the north seeking needle on the compass. The ideal method is a combination of both.

Figure 8 illustrates orientated and non orientated maps. The works "set" or "aligned" are also used to indicate orientation.

Fig. 8 Orientated and non-orientated maps.



Not orientated
Rotate map

Map correctly
orientated

We are lost when we are unable to make the necessary link between what we see around us and the symbolic information presented. The compass is essential for relocation skills where the ability to orientate the map, and check the direction of line and point features, both on the map and in the real world, help to re-establish position.

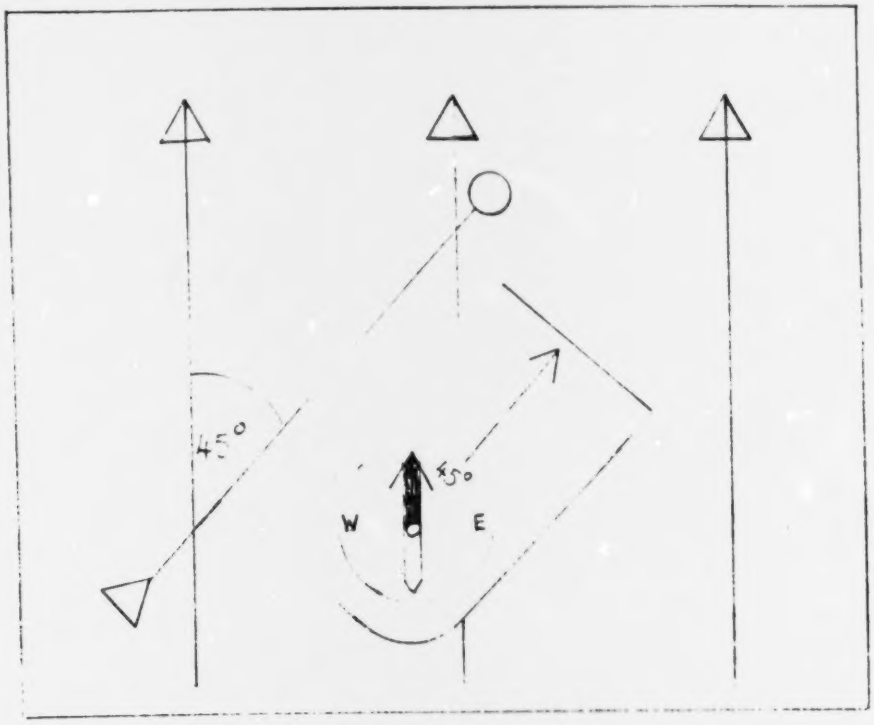
For example, if one arrives at the junction of several features such as a path, stream, fence, track, etc., the map can be orientated or an assessment of the direction of a feature can be made from the map and expressed as a cardinal point, or a bearing, and checked with the compass. Equally the direction of the feature can be taken using the compass first and then the information applied to the map.

Having established position and orientation the next step is to decide which way to travel. This can be solved by taking a compass bearing of the destination.

5.3 Taking compass bearings

It is achieved by taking directional information from the map, transferring the information to the compass and then relating the compass information to the ground.

Fig. 9 Taking a compass bearing

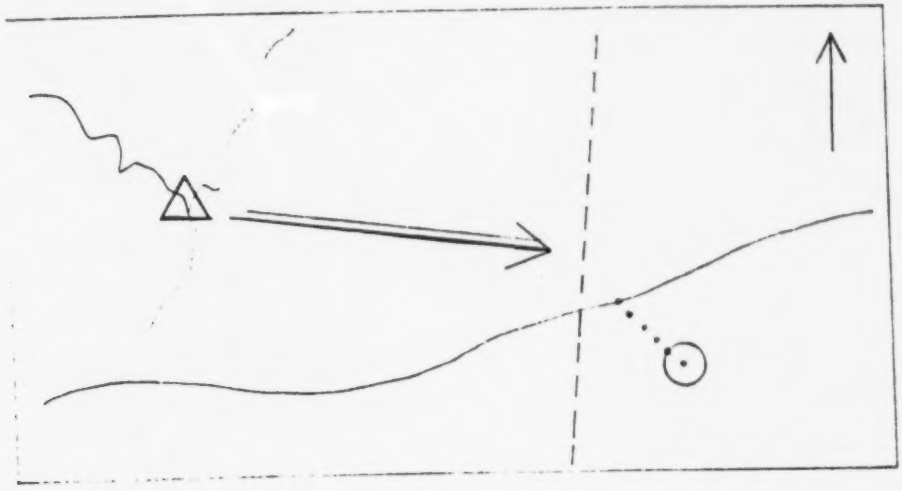


Precise bearings are most useful in locating features over short distances but a knowledge of bearings can also enable a variety of strategies to be used for route simplification. Examples of these strategies include "rough, or coarse, orienteering" and "running on the needle."

5.4 Rough, or course, orienteering

Rough orienteering refers to taking a bearing from the map and using the information to point one's self roughly in the direction you wish to go. It is useful for cutting corners, or crossing terrain to arrive at large, clear, linear features. Fig. 10 shows how the route problem of reaching the control can be simplified by a rough bearing to the N - S track.

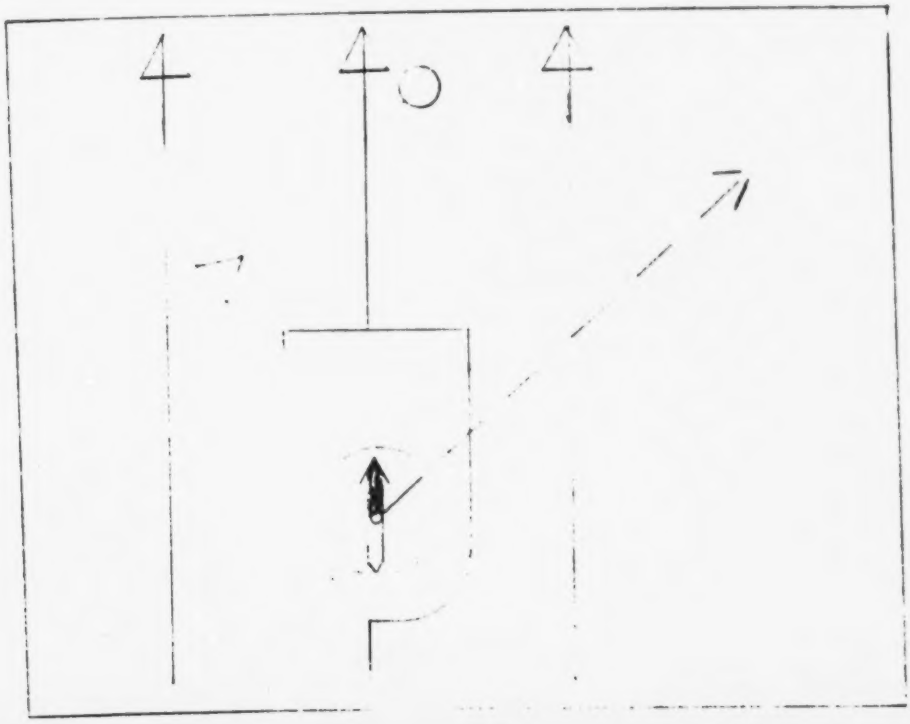
Fig. 10 A Rough bearing to a large feature



5.5 Running on the needle

Running on the needle refers to running at an angle to the magnetic needle. For example, if you decide from the map that you wish to run North or South you follow the red or white end of the needle. If you wish to run NE then you run at one eighth of a rotation to the right of the needle. (See Fig. 11)

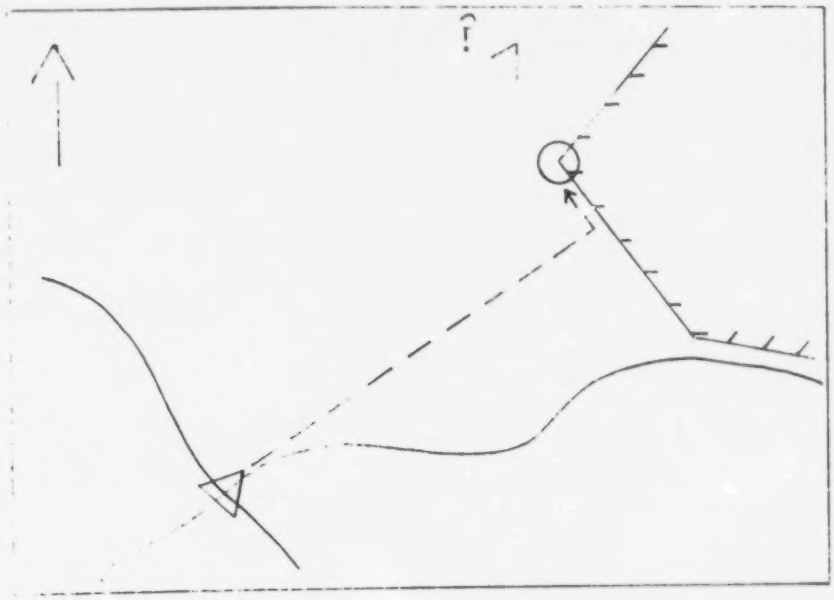
Fig. 11 Running on the needle



5.6 Aiming off

There is one compass skill which uses relative precision with coarse orienteering. It is called "aiming off." This refers to taking a bearing from a map which is deliberately aimed to one side of a control to hit a line, or catching feature. In Fig. 12 the control is on the northern corner of the fence. By aiming to hit the fence and then turning

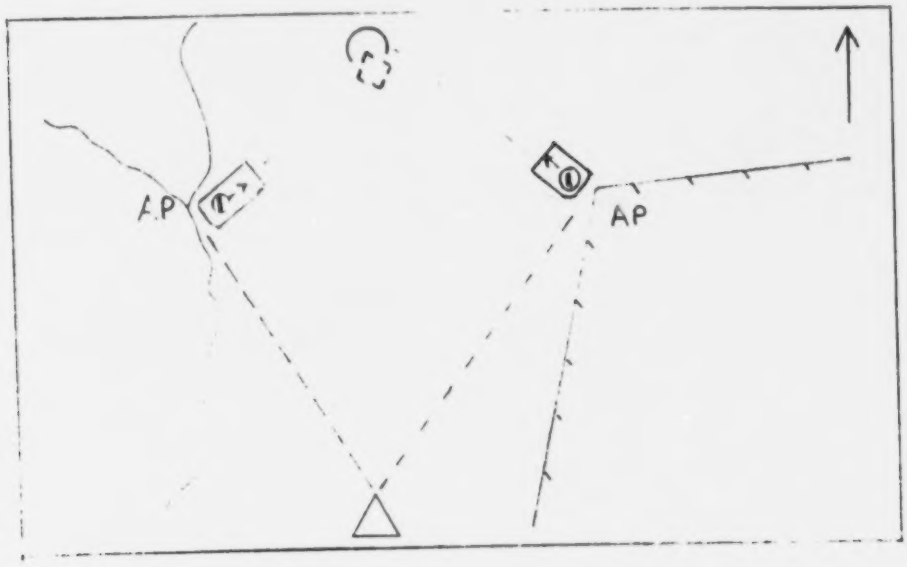
Fig. 12 Aiming off



left it is possible to locate the control. It does not matter where contact is made with the fence, rather that contact is made and the turn executed in the correct direction. Failure to take an accurate bearing, or care in following the bearing could lead to missing the fence and the control.

The above compass skills can be used by the experienced orienteer but the beginner needs to possess the skill of taking bearings with accuracy. The ability to locate a feature from a chosen point near the control (or attack point) by using direction, especially when coupled with distance measuring skills (pace counting), equips the orienteer with skills to navigate with considerable confidence.

Fig. 13 Using accurate bearings from the attack point to the control. Ref. Renfrew et al.



5.7 Equipping the beginner with compass skills

Most beginners however, before using bearings use the compass for locating, or relocating themselves. The ability to have compass skills to avoid getting lost is of prime importance especially when the navigator travels alone.

The instructional guidance given by the compass manufacturers and presented in the coaching literature can be categorised under 'skills learning by a serial approach'. The skill is taught as a series of steps to be carried out in order and close time sequence to give a solution.

It has been argued (Section 3) that a serial approach is limited in its application and that a conceptual approach, in which the key concepts underlying the knowledge of a bearing and their inter-relationships are exposed, equips the beginner with a body of knowledge which can be applied to a range of problems which involve bearings and direction. The beginner not only possesses the skill to take bearings but is given a framework which can be applied to novel situations. The conceptual approach is thus seen as a unifying influence and not one dependent upon memorization and practice.

Most importantly it is argued that the ability to take bearings from a map, to set bearings and to take the bearing of features to check position as an aid to relocation is a key skill in avoiding the awful feeling of being lost, or actually lost. In this condition the novice will be under pressure, and it is important to be equipped with skills to overcome the situation which are not dependent upon routines which might not be fully established.

5.3 The hypotheses

It has been shown in the review of the literature that map and compass skills are a neglected aspect of the curriculum in primary school. Reference has also been made to the prevailing model of learning which underlies coaching of compass skills in orienteering. This is basically a serial one. A contrasting conceptual approach has been put forward (pages 20-23). A number of hypotheses are now put forward which relate to the anticipated advantages of this conceptual approach. There is conflicting evidence on the ability of boys and girls to apply directional skills, and this area is also investigated.

This study presents seven hypotheses, labelled A to G.

Hypothesis A: This study hypothesises that there will be no difference in performance between the conceptual and serial groups in recognising whether a map, possessing magnetic north lines, is correctly orientated.

Hypothesis B: That there will be no difference in the performance of the conceptual and serial group in using the compass to orientate a map.

Hypothesis C: That those children receiving a conceptual approach to learning compass skills, will be able to locate their position on a map with greater accuracy than pupils who receive a serial learning approach.

Hypothesis D: That conceptually taught children will be able to estimate the direction of line and point features in the terrain with greater accuracy than serial taught children.

Hypothesis E: That children who receive the conceptual approach will be able to take a bearing of a destination from a simplified map and locate a feature on that bearing in the terrain more accurately than those receiving a serial approach.

Hypothesis F: That the children receiving a conceptual approach, having taken bearings in the terrain, will be able to locate features on a map with greater accuracy than those receiving a serial approach.

Hypothesis G: Finally, it is hypothesised that the performance of boys and girls does not differ across the range of tests when the results for both teaching methods are combined.*

The sequence of the hypotheses is perceived as reflecting a progression in the demands made on the children's navigational skills. Hypotheses A and B deal with basic aspects of performance which are non-specific for the method of teaching employed. Through hypotheses C to F test demands increase, with the most stringent test of the overall prediction (that the conceptual approach leads to higher-level navigational skill) contained within hypothesis F.

Hypothesis G falls outside this sequence in that it investigates the gender aspect of performance across all the tests.

The relationship between basic compass skills of orienteering, tests and hypotheses is illustrated in Fig. 14.

5.9 Concomitant analyses

1 This part of the analysis addresses the nature of the tests devised to investigate the hypotheses. It examines the interrelationships between the children's test scores with a view to determining whether the a priori construction and labelling of each test is consistent with factors emerging from the analysis. (Factor analysis)

2 The analysis also explores the possibility that the conceptual and serial approaches differentially affect the children's performance across the range of tests, to such an extent that children with two distinctive types of test profile emerge. This involves a statistical analysis which allows the identification of clusters of children whose test results are similar. (Cluster analysis)

Thus the first investigation is concerned with the nature of groupings of test items; the second is concerned with the groupings of children.

* At this stage of the research the possibility of interactions between gender and teaching approaches has not been investigated.

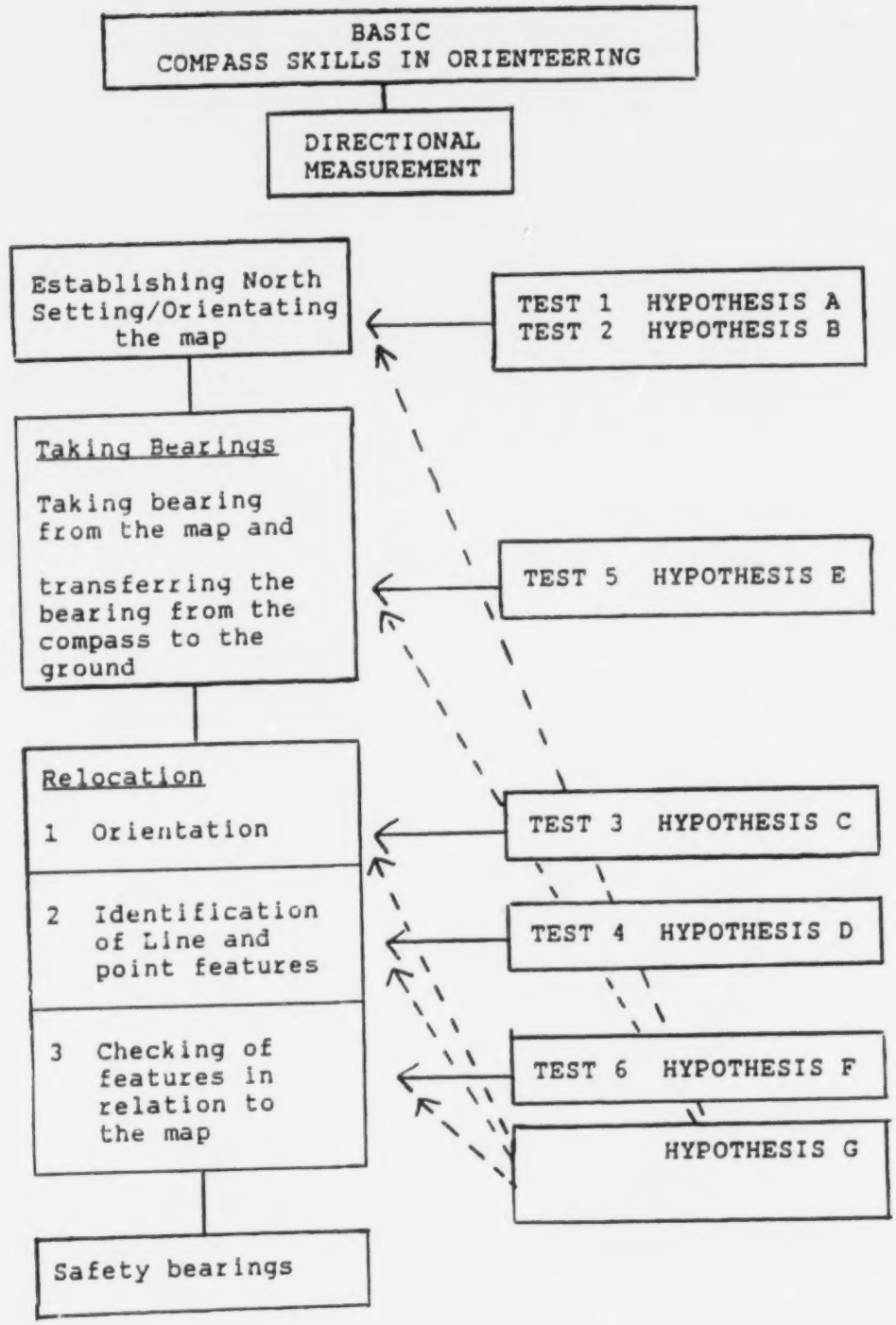


Fig.14 The essential compass skills of directional measurement and their relationship to the research tests and hypotheses.

6.0 Method

6.1 Subjects

The initial sample was 185 children aged 10 plus years drawn from eight primary schools in a Merseyside authority. Complete data was obtained from 148 pupils, of whom 77 (52%) were male and 71 (48%) were female. 37 children were unable to complete one or more tests because of absence and were not considered in the analysis.

Eight teachers, five male and three female were instructed in, and taught the serial and conceptual approaches. The teachers were engaged in a primary/secondary bridging project initiated by the authority and had chosen Mapping Skills as their area of study. The eight teachers were volunteers in choosing to examine compass skills. The intact classes were then randomly assigned to serial (s) conditions or the conceptual (c) condition. Thus four teachers, one female and three male with a total of 68 (45.9%) children followed the serial approach and four teachers, two females and two males, with 80 (54.1%) children followed the conceptual approach.

6.2 The Design and Procedure

The research consisted of four principal stages:

Stage 1 Nov 1989 - Jan 1990
The design of the instructional material

Stage 2 February - March 1990
Induction of the 8 teachers to the instructional materials

Stage 3 April - May 1990
The teaching of compass use to the 8 classes

Stage 4 June, July 1990
Testing of the children in school and local environments

Each stage is outlined in greater detail below.

Stage 1 : The design of the instructional materials

During the period November, 1989 to January, 1990 a training pack was designed for teachers to introduce and teach compass use as part of their summer term project. The material covered six phases of work.

Phase One : Acquiring map drawing and map using skills
Phase Two : The introduction of the map guide compass
Phase Three : An introduction to the protractor compass

Phase Four : Orientating the map with the compass
Phase Five : Setting and reading bearings
Phase Six : Taking and Travelling on bearings

See Figure 15 (p. 41)

Phase One: The first phase was designed to present the learner, initially the teacher and later the children, with a series of activities of a physical and dynamic nature, which promoted the need to acquire and use map drawing, map reading and map utilization skills. The exercises concerned the exploration of different environments, and the discussion of the spatial relationship of features encountered. In order to communicate the activity to others records (maps) were made which promoted discussion and agreement regarding symbolism, orientation, the need for a key, data and titles on the map. The maps were then used to generate problems concerning routes. The participants piloted and recorded the routes and tracked the navigators. Orienteering symbols for start, finish, controls and route indication were introduced and the tasks were completed under time pressure.

Thus at the end of phase one the participants had explored the need to communicate the activity, understood the need for conventions regarding maps, produced maps, used them to design problems for others concerning navigation and provided and received feedback on quality of the map and the problem posed.

Phase Two: Phase one had identified the need for a more refined system for establishing direction and orientation of the map. It was no longer sufficient to state "the top of the map is towards the car park." A simplified compass, the map guide model, was introduced and the participants discovered the parts of the compass and their function. The theme of journeys was continued but now using the compass to travel in directions using the eight cardinal points. Again, the participants designed, as well as solved, the problems.

Phase Three: When confidence had been established in the use of the simplified compass, the protractor compass was introduced. Activities concerning the similarity and differences between protractor compass in different orientations, and between the protractor and map guide compasses were used to promote discussion and understanding of the magnetic needle, the orienting arrow and the direction of travel arrow. The exercises conducted in phase two were repeated and new problems designed. These concerned using the compass to complete routes using multiple changes of direction and the location of point and linear features in the terrain.

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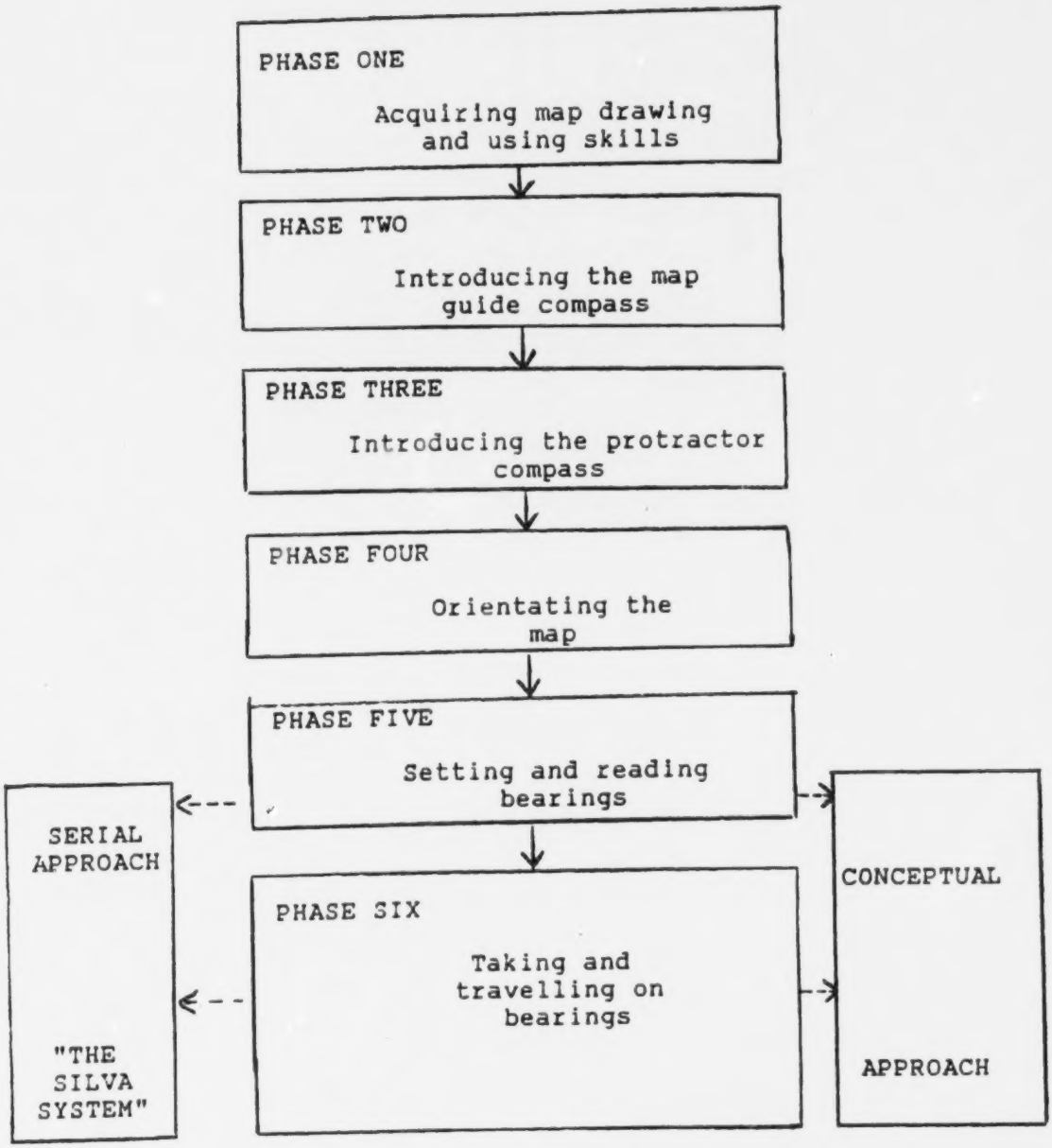

Fig. 15 The six phases of the instructional programme and the place of the two approaches to teaching and application of bearings.

Phase Four: This section of the programme introduced magnetic northlines and indicators on the maps. Now the protractor compass was used to orientate the map. Cardinal points as well as readings in degrees from the scale on the compass housing, were used to indicate the position of point and linear features both on maps and in the terrain. Orientation of the map and therefore the navigator was highlighted, using exercises which emphasised location and the ability to relocate when necessary.

Phase Five: Bearings were introduced, together with the skill of setting bearings on the compass and taking the bearings of features. The bearings were then related to the map. The programme also developed the concept of taking bearings from the map and relating them to the terrain.

Phase Six: The final phase was designed to take a bearing from the map, and to sight and travel along the bearing. Throughout phases 4, 5 and 6 the learner was encouraged to firstly estimate each bearing and then to check the bearing using the compass.

Stage 2 : Induction of the eight teachers

The eight teachers received three 3 hour sessions of induction between February and March, 1990. The sessions were essentially practical with the researchers taking the teachers through each activity. It was important that the teachers understood the activity and experienced the feelings of a learner. Discussion was promoted to cover the objectives, materials and organisational aspects of each exercise. Possible extension activities and games were also considered. Each teacher was provided with the teaching outline, support material for each activity and they were encouraged, between the sessions, to adapt the material for use in their own school buildings and grounds.

At this stage all the teachers were taught the use of the compass using the serial approach advocated by the Silva Step system (see Fig. 4, p. 19) and promoted in the orienteering coaching literature.

The key points of the teaching approach employed were:

a) To examine and demonstrate the skill to give an overview of the task to be learned.

b) To identify, to demonstrate and to explain each part of the skill and its relationship to the overall task.

c) To involve the learner in describing the sequence of activity and to guide others, including the instructor through the skill.

d) To guide the learner through each part of the skill to make smooth transmissions between one section and the next.

e) To fade out the guidance so that the learner takes responsibility.

f) To provide feedback and encouragement at each stage.

g) To provide practice in a variety of situations.

When all the teachers were proficient in compass use the group was split on a voluntary basis, with four teachers agreeing to receive 2.5 hours additional instruction related to the conceptual approach.

It is important to reiterate that the conceptual group were being presented with an alternative approach to presenting and teaching the same objectives as the serial group.

The teachers in the conceptual group examined the nature of concepts, and the relationship between concepts and language. For example, to be able to use the word 'bearing' does not, of itself, imply understanding. A word is not a concept but a symbol which labels a concept.

The introduction to concepts was followed by an analysis, or unpacking of the concept of a bearing. The defining elements were revealed and included turning, rotation, clockwise, anticlockwise, magnetic north, angle, degree and interval.

These sub-elements arose from breaking down the definition of the concept and were placed in a sequence of increasing difficulty. (See Fig. 5, p. 21). In addition, some of the irrelevant features of the concept were considered. For example, it is not normally important to highlight the length of the arms of an angle or bearing, nor the colour used, nor the actual feature being measured. However, they are important in teaching terms as the knowledge relating to the "irrelevant" features allows for variation and cross-checking in the teaching and in the provision of practice.

The analysis of the skill of taking a bearing followed next and revealed that the concepts of matching, or superimposing the magnetic compass needle over the orienting arrow was

important. In turn, this identified the need for an understanding of "parallel", which is present when the markings on the compass housing are placed in relationship to the magnetic north lines. This concept is also needed when the direction of travel arrow is placed along the line between the current location and destination.

The teachers were introduced to the key points of concept teaching which included.

a) Giving an overview of the task to be learned.

b) Explaining the terms to be used in relation to their experience and understanding.

c) Providing simple examples of the essential elements of the concept eg Rotation, from north, in a clockwise direction.

d) Providing further examples but highlighting the important aspects of the concept.

e) Providing examples and discussing whether they belonged to the concept or not, eg Showing a 'bearing' measured in a anticlockwise direction.

f) Encouraging the learner to use his/her own language to explain the concept.

g) Providing clues in the learning and fading them when necessary.

h) Providing feedback and encouragement.

Finally, the group examined how one could assess whether the concept was attained.

It was agreed that the learner should be able to select examples of the concept, recognise examples, state why an example fitted the concept or not and solve problems which involved the knowledge of the concept.

In addition to an understanding of the nature of concepts, task analysis and how concepts could be taught and assessed the group agreed to conduct a pretest to determine whether the children possessed the sub-elements of the concept. The ability to estimate would be checked also.

During the course of the induction the group became aware that North was very difficult to explain and so concept learning by analogy was introduced. Though this led to

stereotypical statements such as 'Eskimos live at the North Pole', 'Penguins are found at the South Pole', these were considered helpful in explaining.

The teaching package, containing games and exercises for both the serial and conceptual groups, was supported by guidance on the key elements of the teaching sequence and prompts for learning.

Stage 3 : The teaching of compass use to the eight classes.

The teaching was conducted during April and May, 1990 as part of the Summer Term mapping project. Teachers spent approximately two hours per week on the entire package from elementary navigation, map drawing and use, orientation with and without compass and bearings work.

Throughout the teaching period the research team provided practical support, help, encouragement and feedback to each group.

Stage 4 : Testing of the children

The tests, together with a screening test, were conducted both in school and in local parkland environment as detailed below.

6.3 SAMPLE SCREENING

Orientation test

Aims

This test was used primarily as a threshold or screening test. The main aim of this test, was to ascertain each subject's ability to read a simplified map and use this map to follow a route involving choice of right, left and forward directions. Any subjects who failed to cope with the tests would either be screened out of the main project or, where appropriate, be identified for future follow up and qualitative investigation.

The sample

The sample of 185 primary children were selected from eight Primary schools. They were all 10 years of age or older on the 1st September 1989.

Methodology

Each subject completed two linear pathway tests across a marked grid pattern. Test A, a familiarisation exercise, was a simple test, where subjects traversed to the opposite side of the grid (Fig. 16). Test B, the screening test, was more complex, with subjects starting from one side and finishing on the adjacent side (Fig. 17).

A 40 ft. square grid pattern of 10 ft. squares was used for both of the tests. The grid was marked with tape onto an outdoor grass playing area. Each junction of the grid was marked with a small upright flower pot. This allowed for some (or all) of the junctions to be marked or numbered by inserting a small card disc into the bottom of the pot. This meant that to actually see or read the marking on the disc, then the subject had to walk right up to the pot. That is, directional decisions were not influenced by previewing the marked discs.

Subjects were presented with a plan of the grid with a pre-marked route, symbolised by a red line, traversing the grid and following the lines. The starting point was symbolised with a red triangle and all of the junctions which the line passed through were all identified by a red, circled number. This corresponded to the numbered disc on the actual grid and included the finishing junction symbolised by double circle. This form of symbolisation using red lines to mark routes and red triangles and a double circle symbol for the start and finish of any route was going to be the standard format for all map routes in the Project.

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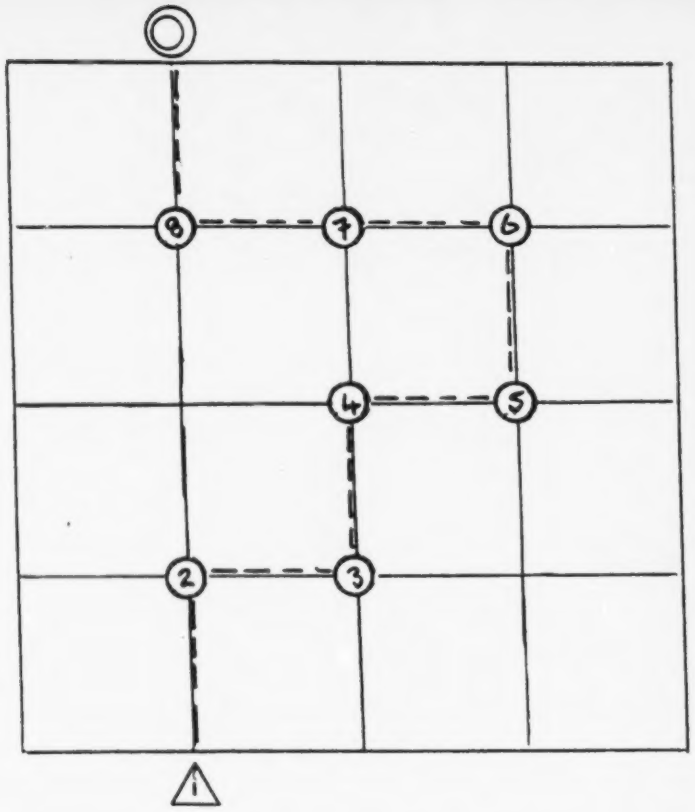
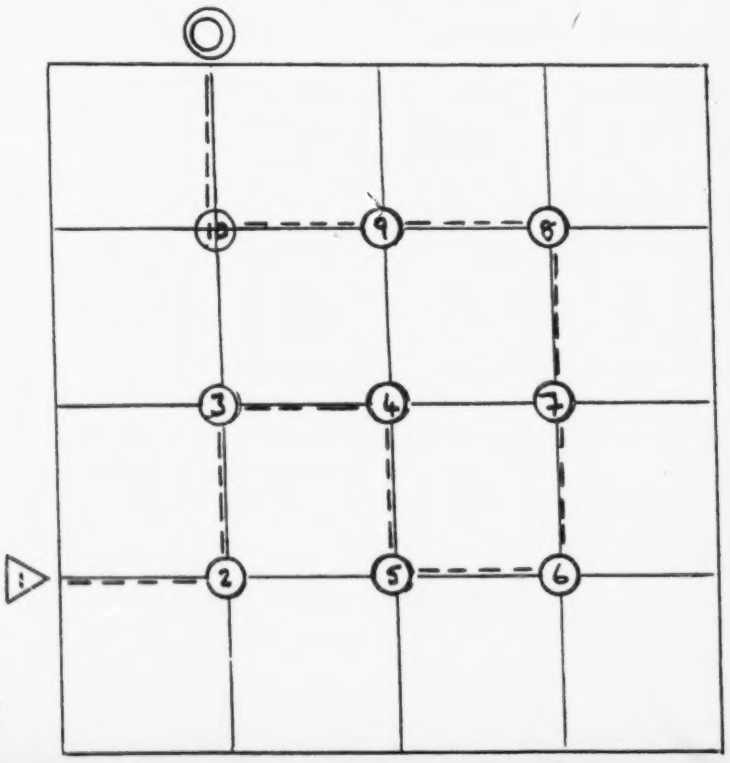
Fig. 16 Test A Grid



The instructions were to use the pre-marked route on the plan to cross the actual grid, visiting the marked junctions in the correct numerical sequence. In the event of an incorrect turn at a junction, identified by the feedback from the numbered pots, then subjects could attempt to identify their error and continue. If this caused evident confusion, or more than 3 errors were made at a single junction, then guidance would be given.

Fig. 17 Test B Grid



Data Collection

Each data record noted the number and type of error made by each subject.

A separate data record was completed for each subject (Fig. 18). Each data point was coded for ease of analysis. Each school and subject were given identification numbers, which were retained for the term of the Project and for all subsequent experimental testing.

The coding system adopted was as follows:-

A = School number
B = Subject number
C = Sex 1 = M, 2 = F)
D = Handedness (1 = L, 2 = R)
E = Total errors
All other data points = Sequence of directional error at each decision point.

NB. There was a potential total of three errors for each decision point. 0 = A correct decision
e.g. 1 2 0 represents an error to the left followed by an error to the right followed by a correct move (no error) for one particular decision point.

All of the subjects displayed an ability to use the simple map and to follow a pre-defined route. There was no significant difference between the total error raw scores of the boys and the girls. Neither was there any significant difference between the total error raw scores of the right-handed and left-handed subjects.

Fig. 18 Example of score sheet

Number _____ Name _____

Age _____ M / F _____ LH / RH _____

Sample _____

Start time _____ Finish time _____ Elapsed time _____

Decision Point	Correct	Error				Guidance given
		L	R	F	B	
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
Additional Information						

6.4 THE SIX TESTS

Six tests were devised to cover the range of basic compass skills necessary to participate in orienteering. The tests were sequential, each building upon the other and increasing in difficulty.

In order of presentation the objectives of each test were as follows.

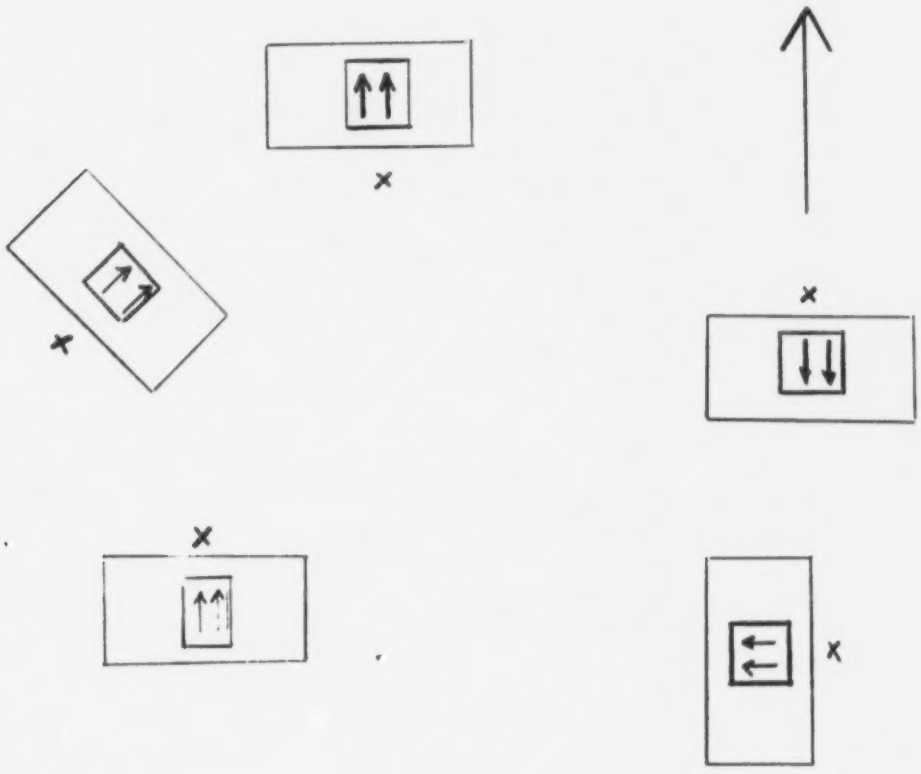
Test	Purpose
One	To use a compass to decide whether a map, possessing magnetic north line was correctly orientated.
Two	To accurately orientate a map using a type 3 Silva compass.
Three	To identify location on a map by using the compass to orientate the map and map reading.
Four	To estimate and then measure as bearings the direction of linear and point features in the terrain.
Five	To estimate a bearing from a map, to calculate the bearing and then to identify an object nearest the line of travel.
Six	To calculate and measure the bearing of a linear feature (a path), and when given one's current location on a map indicate the feature measured.

The relationship of the tests to the basic compass skills is illustrated in Fig. 14

TEST ONE: To use a compass to decide whether a map, possessing magnetic north line was correctly orientated.

Test Layout and materials

Each repetition of test one, within the different schools, was identical in experimental layout and procedure. Five non-magnetic tables were arranged in a specific, directional orientation as shown in the diagram below.



Five black and white orienteering maps of local parks were presented face up on each table with the edges of the map parallel with the edges of the tables. The magnetic north lines on each map were clearly designated. Also the arrowhead of these lines was coloured red and enlarged to twice normal size.

Maps (a) and (d) were correctly orientated to magnetic north. The remainder were misaligned as follows: (b) 180 degrees out; (c) 270 degrees out; and (e) 45 degrees out.

Test procedure

Individual subjects approached each table in the order (a) to (e) and were positioned at point x as shown on the diagram. Note that whilst map (d) is correctly orientated the subject is presented with the item in a different situation than in item (a).

The subject was asked to indicate the north seeking needle on the compass and to point to magnetic north lines on the map. The subject was then instructed to use their compass to decide whether the map was correctly orientated to magnetic north. At this stage they were asked if there was anything they did not understand. The procedure was repeated at each table.

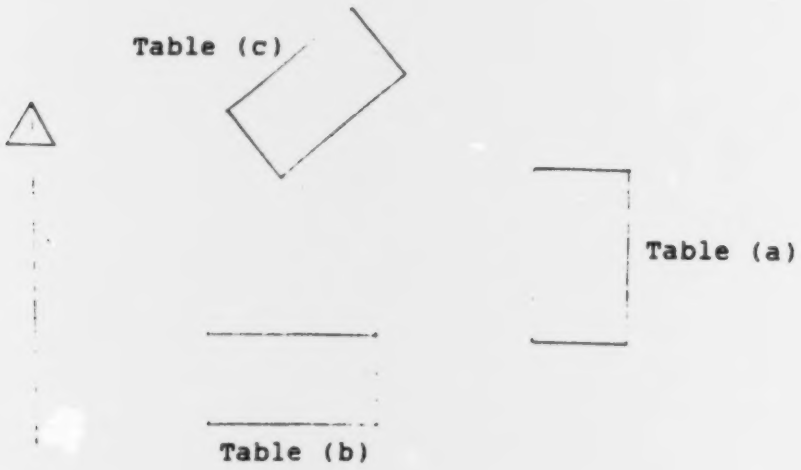
Method of scoring

One point was given for a correct response and no points for an incorrect response.

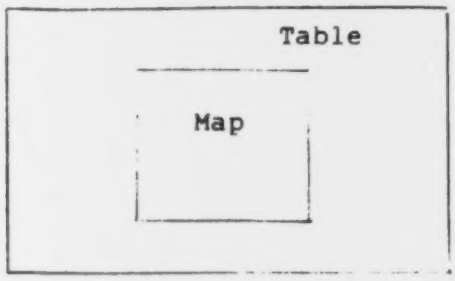
TEST TWO: To accurately orientate a map using a type 3 Silva compass.

Test layout and materials

Each repetition of Test two, within the different school buildings, was identical in test layout and procedure. Three non-magnetic tables were arranged in a specific directional orientation as shown in the diagram below.



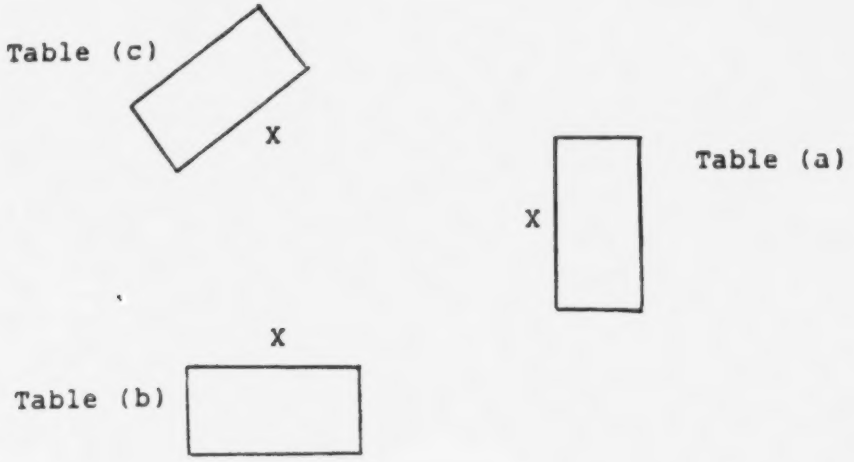
A simple black and white Orienteering map was placed face down on each table with the edges of the map parallel with the edges of the able as shown in the following diagram.



Each subject was given a Type 3 SILVA compass.

Test Procedure

Individual subjects approached each table in the order (a), (b), (c) and were positioned at point X. See diagram.



Subjects were then instructed to turn the map over and to use their compass to place the map on the table so that it was correctly orientated to Magnetic North. At this stage, they were asked if they understood the instructions. When the subject was satisfied with the map orientation, then the map was "fixed" in position with a removable adhesive material.

This procedure was repeated at table (b) and table (c) and then the tester measured the degree of accuracy of orientation to Magnetic North using a Type 3 SILVA compass.

Method of Scoring

Each map position was carefully measured for degrees of error from Magnetic North.

Errors from 1 degree to 10 degrees scored 3 points
Errors from 11 degrees to 20 degrees scored 2 points
Errors from 21 degrees to 30 degrees scored 1 point
Errors $\geq$ 31 degrees scored 0 points

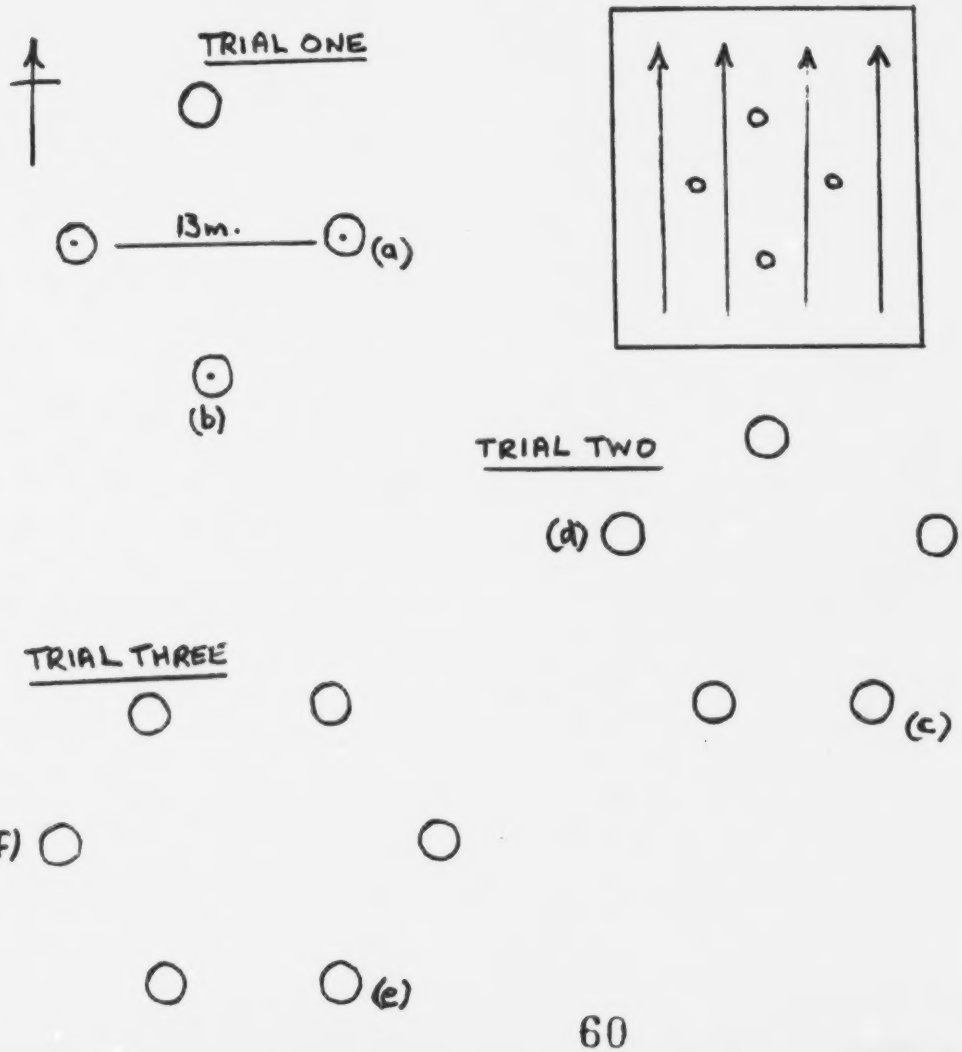
TEST THREE: To identify location on a map using the compass to orientate the map and map reading.

Test Layout and materials

A symmetrical array of 4 identical traffic cones was positioned on the school playing field each cone was 6.5m from a central point and positioned at 90 degree intervals radiating from North.

A laminated card, representing a simple map, was prepared showing magnetic northlines with red arrowheads and with the position of the cones indicated by a solid, red circle.

Two additional arrays were prepared one of five points, with the cones at 72 degree intervals from north and other with six points, the cones positioned 60 degrees from magnetic north. As in the first array each cone was 6.5m from a central point. Laminated maps were prepared as above. Each subject was provided with a Type 3 Silva compass. The square, pentagonal and hexagonal arrays and maps are presented below.



Test Procedure

Individual subjects were taken to cone (a) on the square array and positioned on the outside of the array facing directly over the cone towards the centre of the array. The subject was shown the map of the array with the magnetic northlines pointing to the centre of the array. The subject was asked to use the compass together with the map to work out which cone they were standing at and to point to the cone on the map. At this stage the subject was asked if there was anything they did not understand. On completion of the task the subject returned the map to the tester and was taken around the outside of the layout to a second position on the array. This is shown as point (b) on the diagram below and the activity repeated.

The procedure was repeated on the pentagonal and hexagonal arrays using points (c) to (f) as illustrated.

Method of scoring

One point was given for a correct response and no points for an incorrect answer.

TEST FOUR: To estimate and then measure as bearings the direction of linear and pointfeatures in the terrain.

Test Layout and materials

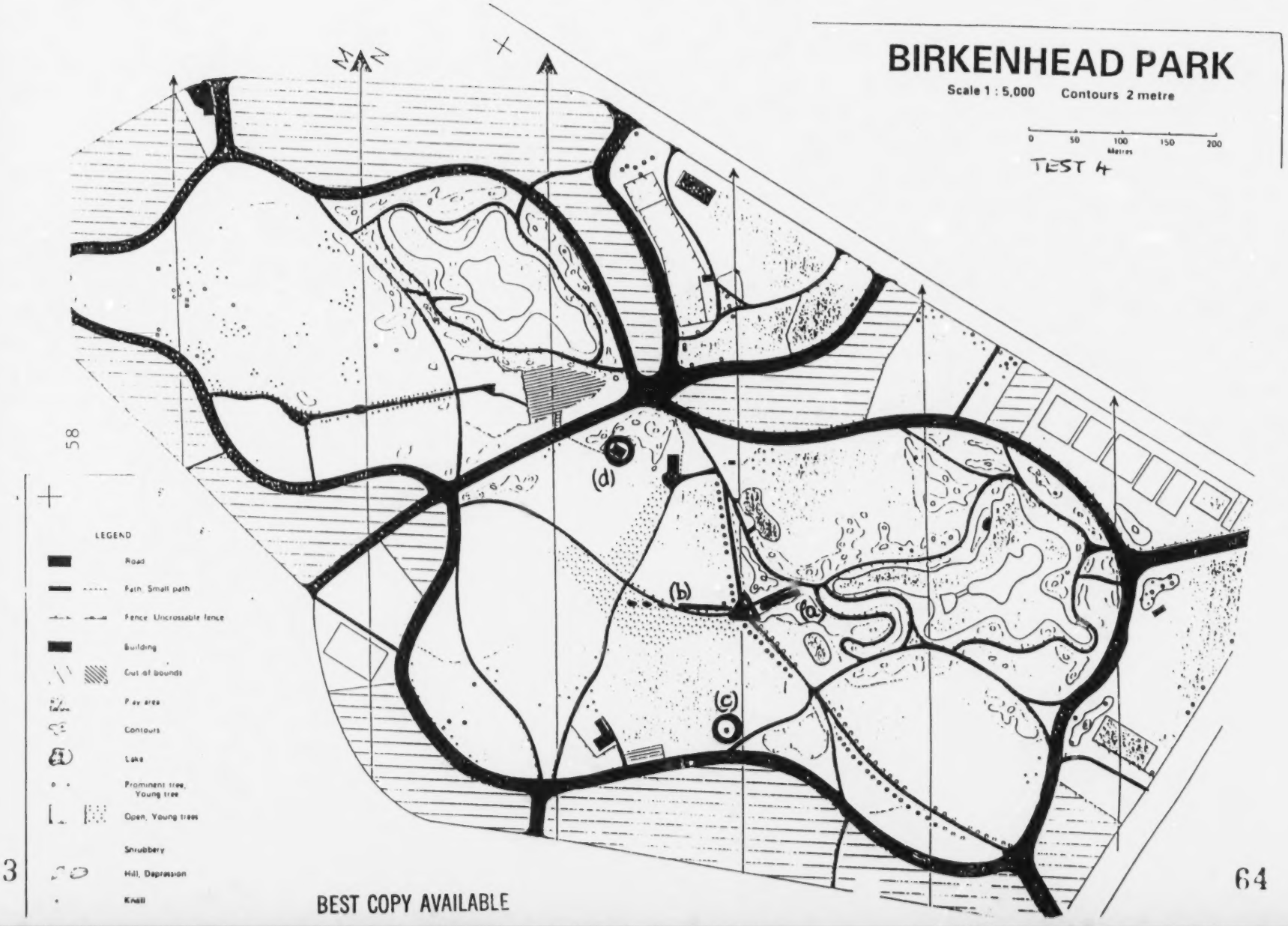
Test Four was conducted in an Urban Park environment at the junction of four paths shown by the red triangle on the map below. A circle one metre diameter was marked at the centre of the junction. An orienteering control marker, consisting of a red and white clock triangular prism was attached to a cane due north of the junction at a distance of 50 metres. Each subject was provided with a Type 3 Silva compass and a clipboard containing a score sheet and pencil.

Test procedure

Subjects, up to three at a time were taken to the circle at the centre of the junction and issued with compasses. They were asked to sight along the north seeking needle and identify objects including the control marker. The marker was established as being North of their position. The compasses were collected in and the score sheet distributed. The task was explained in that they would estimate and record the bearing of four features in the terrain. The features were two paths (a) and (b) and two point features, building (c) and building (d). The clipboards and score sheets were placed five metres from the junction so that responses could not be seen by other subjects. The two paths were indicated and estimates taken, then the two point features were indicated and the estimates recorded. Subjects were asked if there was anything they did not understand and then they worked at their own pace. They were then informed that they should check the estimated bearings by measuring them with the compass. The bearings were taken and recorded again at their own pace. On completion the clipboards, score sheets and compasses were returned to the tester.

Method of Scoring

The Estimated bearings were scored and coded on the degree of accuracy in 10 degree error bands. For example answers within 10 degrees scored 3 points, between 11 degrees and 20 degrees, scored 2 points, between 21 degrees and 30 degrees scored 1 point. Answers with errors over 31 degrees scored no points. The maximum score for a pupil scoring both estimate and measurement accurately is six points per trial for each of the four trials, making 24 points in all.



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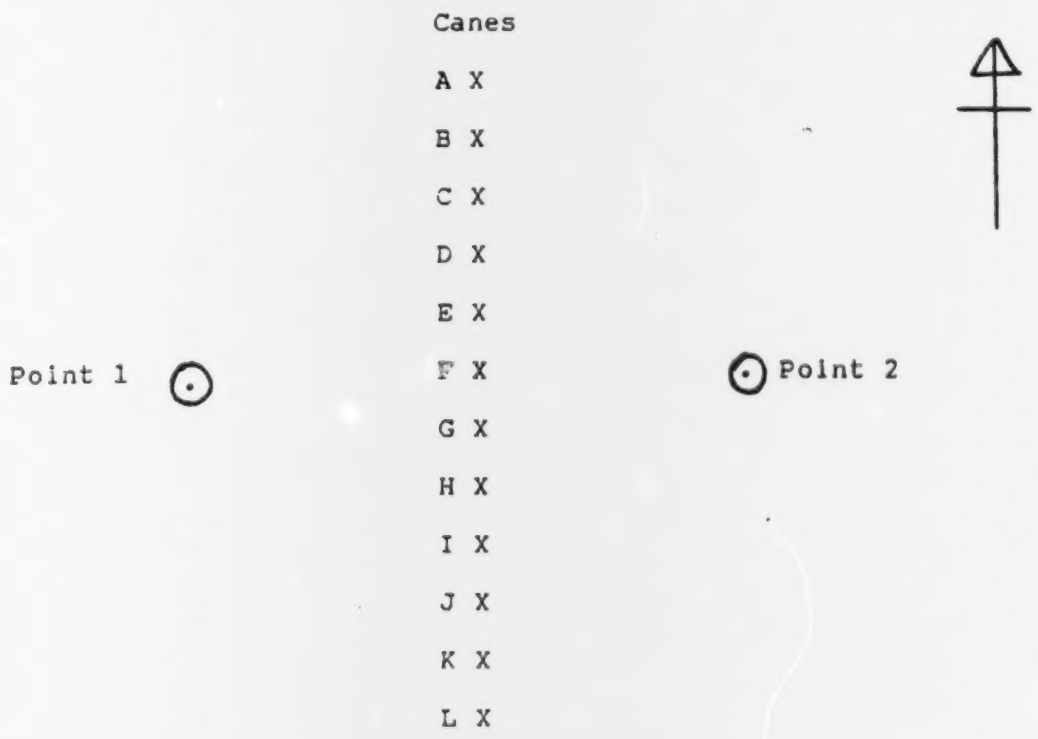
TEST FIVE: To estimate a bearing from a map, to calculate the bearing and to identify an object nearest the line of travel.

Test layout

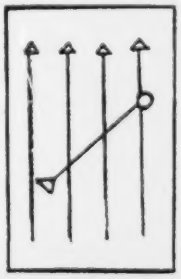
A line of eleven canes were positioned on the school playing fields so that they were aligned to a North - South orientation. The canes were accurately placed at measured intervals so that each cane was on a 10 degree interval bearing from given points 12.2 metres due West and East from the central cane. The diagram below explains this layout more clearly.



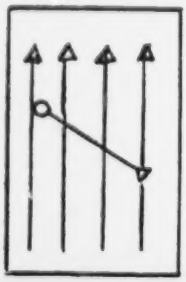
Each cane was identified by a large lettered card from A on the northern most cane to L on the southern most cane, as shown in the diagram.

Four covered cards were prepared. These were marked with Magnetic North lines and arrows and in addition, each card was marked with a red starting triangle and a red destination or control circle. The bearing from the triangle to the circle, which were joined by a red line, was set differently on each card. These different bearings are shown clearly in the diagram below.

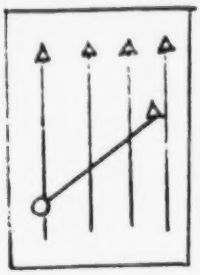
Card (a)



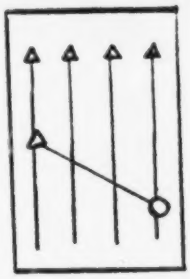
Card (b)



Card (c)



Card (d)



Each subject was provided with a Type 3 SILVA compass.

Test Procedure

Individual subjects were taken to point 1 where they were given card (a) and asked to estimate what they thought the bearing would be, without using their compass, assuming they wanted to travel from the triangle to the circle. At this stage subjects were asked if they understood the instructions for the exercise. Subjects were then asked to use their compass to measure the actual bearing from the triangle to the circle. Finally, subjects were asked to use this bearing and identify, from point 1, which letter or cane was in line with this bearing.

This procedure was repeated with card (b) from point 1 and with cards (c) and (d) from point 2.

Method of Scoring

Score sheets recorded the estimated and the actual bearings for each of the four cards. These error scores were then recorded according to the size of error. More precisely the errors were coded as follows:-

Card (a) actual bearing = 50 degrees
40 degrees - 54 degrees = scored 3
35 degrees - 44 degrees = scored 2
55 degrees - 64 degrees = scored 2
25 degrees - 34 degrees = scored 1
65 degrees - 74 degrees = scored 1
<25 degrees and >74 degrees = scored 0

Card (b) actual bearing = 120 degrees
115 degrees - 124 degrees = scored 3
105 degrees - 114 degrees = scored 2
125 degrees - 134 degrees = scored 2
95 degrees - 104 degrees = scored 1
135 degrees - 144 degrees = scored 1
<95 degrees and >144 degrees = scored 0

Card (c) actual bearing = 230 degrees
225 degrees - 234 degrees = scored 3
215 degrees - 224 degrees = scored 2
235 degrees - 254 degrees = scored 2
205 degrees - 214 degrees = scored 1
245 degrees - 254 degrees = scored 1
<205 degrees and >254 degrees = scored 0

Card (d) actual bearing = 300 degrees
295 degrees - 304 degrees = scored 3
285 degrees - 294 degrees = scored 2
305 degrees - 314 degrees = scored 2
275 degrees - 284 degrees = scored 1
315 degrees - 324 degrees = scored 1
<275 degrees and >325 degrees = scored 0

The application of the bearing was measured as being correct, score = 1, if the subjects used the correct process for using a bearing to show direction, although this may have been based on using an inaccurate bearing. The use of an incorrect process was scored as 0 although "guesswork" may have produced an apparently "correct" result. Again a degree of error was accepted. That is, subjects were given a band width of three canes or letters for their results. For example, if C was the correct response then both B and D were acceptable responses.

TEST SIX: To calculate and measure the bearing of a linear feature (a path) and when given current location on a map to indicate the feature marked.

Test layout and materials

Test six, as the final test, used an Urban Park environment. The simple black and white Orienteering map shown overleaf represents the area used.

Two path junctions, marked X1 and X2 on the map, were selected as appropriate sites for this applied experiment. Individual maps were prepared with red triangles marking the site of junction X1 and junction X2. Subjects were given a Type 3 SILVA compass.

Test Procedure

Individual subjects stood at junction X1, at a point marked on the ground, and were asked to first estimate the bearing of path (a) without using their compass and then to use their compass to take the actual bearing along the path. As in previous tests, subjects were asked if they fully understood the instructions. Finally subjects were then shown the appropriate map of the "Park" and asked to identify, on the map, the path they thought they had taken their bearing along. That is, assuming they had been standing at the path junction marked with the red triangle on the map. This procedure was repeated for path (b) and then replicated at junction X2 where subjects estimated and measured bearings and then identified paths using paths (c) and (d).

Method of Scoring

Estimated and actual bearings were scored and coded on their degree of accuracy in 10 degree error bands. More precisely the scoring for each path was:-

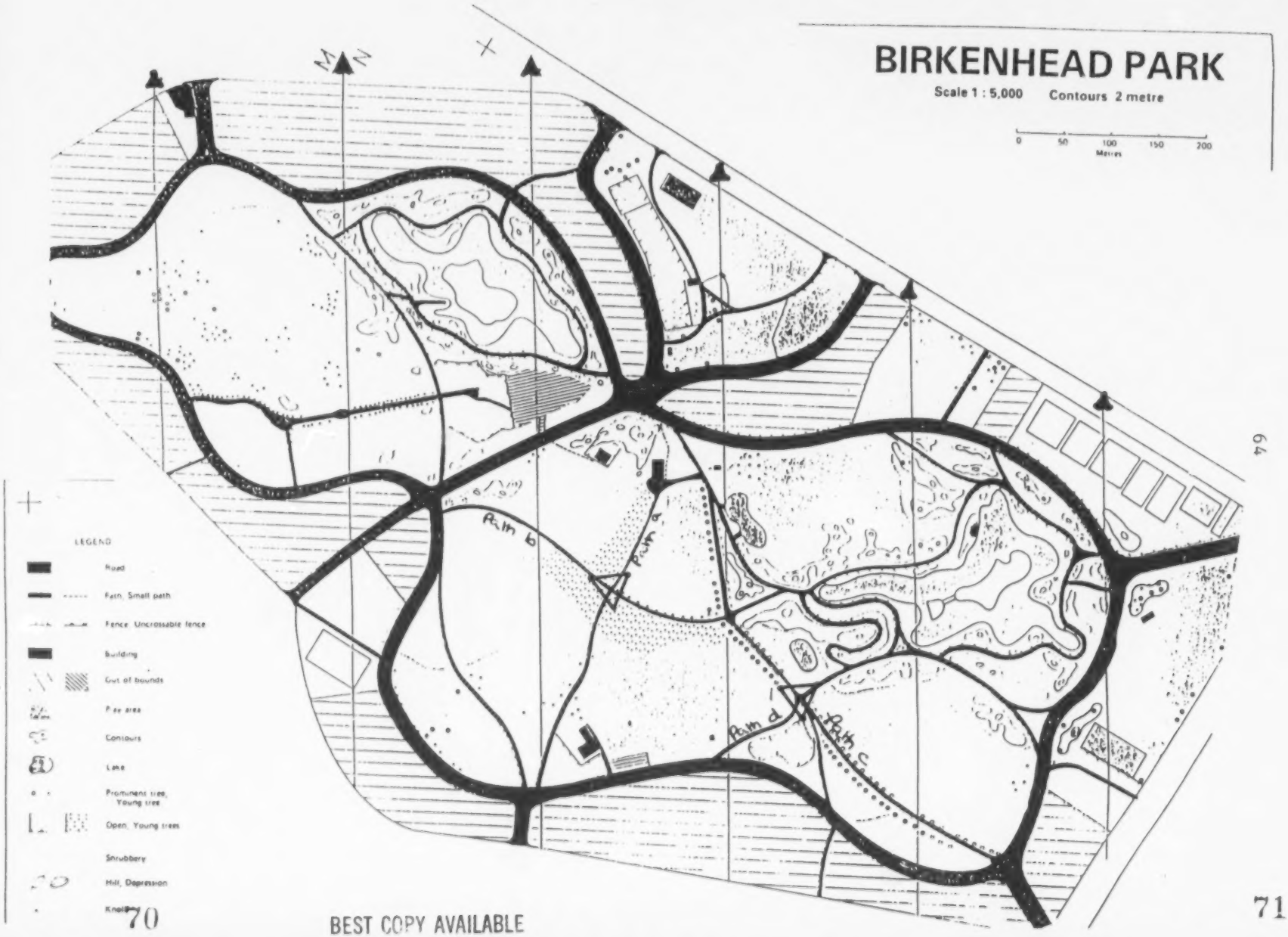
Path (a) actual bearing 28 degrees
24 degrees - 33 degrees = scored 3
14 degrees - 23 degrees = scored 2
34 degrees - 43 degrees = scored 2
4 degrees - 13 degrees = scored 1
44 degrees - 53 degrees = scored 1
<4 degrees and >53 degrees = scored 0

Path (b) actual bearing 308 degrees
304 degrees - 313 degrees = scored 3
294 degrees - 303 degrees = scored 2
314 degrees - 323 degrees = scored 2
284 degrees - 293 degrees = scored 1
324 degrees - 333 degrees = scored 1
<284 degrees and >333 degrees = scored 0

Path (c) actual bearing 140 degrees
136 degrees - 145 degrees = scored 3
126 degrees - 135 degrees = scored 2
146 degrees - 155 degrees = scored 2
116 degrees - 125 degrees = scored 1
156 degrees - 165 degrees = scored 1
<116 degrees and >165 degrees = scored 0

Path (d) actual bearing 223 degrees
291 degrees - 228 degrees = scored 3
209 degrees - 218 degrees = scored 2
229 degrees - 238 degrees = scored 2
199 degrees - 208 degrees = scored 1
239 degrees - 248 degrees = scored 1
<199 degrees and >248 degrees = scored 0

Correct path identification on the map was scored as 1 and incorrect path identification was scored as 0



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Sample Score Sheet

TEST 6

Name:	School:											
	1a	B	F	1b	B	F	2a	B	F	2b	B	F

7 RESULTS

7.1 MAIN HYPOTHESES

Hypothesis A: That there will be no difference in performance between the conceptual and serial groups in recognising whether a map, possessing magnetic north lines, is correctly orientated.

Results on Test 1 were negatively skewed. An optimal split produced the following table.

Test 1

	Low	High
Serial	12	56
Conceptual	27	53

Chi-square 5.78, $p < .05$

Hypothesis A is not confirmed. The results show a significant tendency for the children receiving the serial approach to perform better.

Hypothesis B: That there will be no difference in the performance of the conceptual and serial groups in using the compass to orientate a map.

Results on Test 2 were similarly negatively skewed. An appropriate split produced the following distribution.

Test 2

	Low	High
Serial	6	62
Conceptual	21	59

Chi-square = 4.64, $p < .05$

Hypothesis B is not confirmed. The results show a significant tendency for the children receiving the serial approach to perform better.

Hypothesis C: That those children receiving a conceptual approach to learning compass skills, will be able to locate their position on a map with greater accuracy than pupils who receive a serial learning approach.

Although the score distribution was not normal, it was not necessary to telescope cells for the computation of chi-square.

Test 3

	Low 0	1	2	3	4	5	High 6
Serial	5	7	9	12	10	12	13
Conceptual	9	9	9	11	5	6	31

Chi-square = 11.57, not significant.

Hypothesis C is not confirmed. There is no evidence that the conceptual approach has led to children being more accurate in locating position on a map.

Hypothesis D: That conceptually taught children will be able to estimate the direction of line and point features in the terrain with greater accuracy than serial taught children.

The distribution of scores was normal. It was necessary to telescope cells for chi-square.

Test 4

	Low 0-8	9-12	13-16	High 17-24
Serial	18	20	19	11
Conceptual	5	18	27	30

Chi-square = 12.31, $p < .001$

Hypothesis D receives strong support. The conceptual approach has led to many more children being able to estimate the direction of line and point features in the terrain with accuracy.

Hypothesis E: That children who receive the conceptual approach will be able to take a bearing of a destination from a simplified map and locate a feature on that bearing in the terrain more accurately than those receiving a serial approach.

The distribution of scores was normal. It was necessary to telescope adjacent cells for the computation of chi-square.

Test 5

	Low 0-11	12-16	17-20	High 21-28
Serial	16	23	17	12
Conceptual	8	13	17	42

Chi-square = 16.07, $p < .001$

Hypothesis E got strong support. The conceptual approach has led to many more children being able to take bearings of a destination from a map and to locate a feature on that bearing in the terrain than those using the serial approach.

Hypothesis F: That the children receiving a conceptual approach, having taken bearings in the terrain, will be able to locate features on a map with greater accuracy than those receiving a serial approach.

Some evidence of skew in the distribution was present. An appropriate telescoping of the cells produced the following:

Test 6

	Low 0-10	11-13	High 14-16
Serial	31	27	10
Conceptual	17	40	23

Chi-square = 11.08, $p < .001$

Hypothesis F receives strong support. The conceptual approach has resulted in many more children being able to locate a feature on a map, having taken a bearing of that feature, with greater accuracy than those receiving a serial approach.

Hypothesis G: That the performance of boys and girls does not differ across the range of tests when the results for both teaching methods are combined.

Test 1

	Low	High
Boys	9	68
Girls	30	41

Chi-square = 16.24, p <.001

Test 2

	Low	High
Boys	8	69
Girls	19	52

Chi-square = 5.59, p <.02

Test 3

	Low 0-2	3-5	High 6
Boys	21	29	27
Girls	27	27	17

Chi-square = 2.87, NS

Test 4

	Low 0-11	12-16	High 17-22
Boys	19	33	25
Girls	26	29	16

Chi-square = 3.11, NS

Test 5

	Low 0-14	15-20	High 21-27
Boys	18	33	26
Girls	21	22	28

Chi-square = 2.28, NS

Test 6

	Low		High
Boys	20	23	34
Girls	28	25	18

Chi-square = 6.09, p <.05

Factor Analysis

Scores were subjected to a principal components analysis followed by Varimax rotation to enhance factorial identity.

Fourteen factors emerged with eigenvalues greater than one. The first eight factors, which accounted for 50% of the total variance, were considered worthy of note.

Factor One accounted for 14.8% of the variance; Factor Two accounted for 8.0% of the variance; and Factor Three accounted for 6.0% of the variance.

The percentage of the variance accounted for by Factors Four to Eight fell between 3% and 6%. These last factors are, therefore, very small in size.

The test items which load on the eight factors are shown in Table 1.

The most likely fit between the factors which have emerged and the skills being assessed by test items is shown below in Fig. 15.

On the whole there is a considerable overlap between the a priori skills grouped together and labelled in the individual tests and the separation by factors. Factor one corresponds to certain aspects of Test 5. Factor two overlaps completely with Test 3. Factor three is substantially Test 4, but there is some overlap with Test 6. Factor four is defined by Test 1. Factor five is Test 2. Factor six is made up of two items from Test 6. Factor seven crosses test boundaries (including a doublet from Test 6). Factor eight corresponds to the remaining items of Test 5.

Cluster Analysis

A cluster analysis on a subset of the data was performed in order to examine the possibility that the two contrasting approaches to teaching had produced similarities in test performances within each group of children. Given the unequal numbers in the two groups (Ns = 68; Nc = 80), the group sizes were made equal by randomly eliminating children from the conceptual group. For the purposes of the cluster analysis then, both groups contained 68 children. The data were identical to that used for the factor analysis, ie. item scores from all the tests, totals excluded.

The dendrogram is shown in Fig. 20 (p.73). 20 clusters emerged, which show a good deal of differentiation across levels. Nevertheless inspection reveals a clustering of children given the serial approach to the left of the dendrogram, with children given the conceptual approach to the right. At levels 10/11 of the cluster analysis the structure shows one grouping to be made up of 66% serial and 34% conceptual, with the proportions reversed in the other group. Thus there is some evidence for the hypothesis that the two teaching approaches have resulted in different profiles of performance.

FACTOR	ASSOCIATED NAVIGATIONAL SKILL	TEST
1	Taking bearings from a map	5
2	Relocation of position from terrain to map	3
3	Taking bearings from terrain	4 + some of 6
4	Is the map orientated	1
5	Using compass to orientate map	2
6	Using a bearing from terrain to map	Part of 6
7	Mixture of skills: a) Orientation of map b) Using a bearing c) Taking a bearing	Parts of 1 5 6
8	Apply bearing to terrain	5

Figure 19 The match between emergent factors and the navigational skills being assessed

ROTATED FACTOR MATRIX:

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6	FACTOR 7	FACTOR 8
V32	.82858	.01538	-.03856	.05933	.06541	.04931	-.02145	-.08236
V31	.78442	.09217	.05358	-.07594	.04836	.04533	.27029	.00369
V33	.78049	.10464	.01618	.03853	.00050	.17104	.16794	.15499
V34	.71284	.16365	.01709	-.00153	.25191	.09229	-.05729	.14193
V27	.37254	.21835	.37082	-.20933	.11987	.20682	-.02892	-.23250
V16	.03841	.74637	.00538	.04564	-.11903	.12940	.08556	-.03089
V17	.16123	.72993	.09792	-.05175	.19764	-.04587	-.09778	.08076
V18	.19332	.70760	-.05100	-.04287	.12528	.13345	-.11874	.02142
V15	.03035	.69313	.03341	.25255	.06240	.11753	.07255	.04906
V26	.08681	-.07759	.67986	-.10527	.11935	.06348	.13371	-.05126
V25	.03644	.19383	.65061	-.10454	.06837	-.01595	.07430	.06184
V24	-.08889	-.01970	.61957	.07191	-.05462	.08240	-.01424	.09122
V43	.04492	-.03822	.59036	.17881	.04226	.18791	.31837	.16951
V45	-.06774	.12685	.48120	-.06059	-.16496	-.23073	.18136	.23159
V20	.25975	-.02585	.43615	.43956	-.13612	-.01727	-.01041	.05908
V9	-.01954	.14617	-.09617	.77991	.00734	.02634	.00663	.00183
V8	-.02250	-.05519	.03851	.63782	.01386	.08279	-.09215	.12356
V7	-.08232	.15863	-.04021	.60691	.02263	.11279	.05262	-.18531
V12	.02647	.12355	.11490	.04147	.81193	-.00859	.05426	-.03344
V10	.14628	.04855	-.04721	.19014	.74004	.13220	.08052	-.08016
V11	.27774	.08244	.05710	.38714	.60305	-.00539	.01907	.11901
V44	.10632	.12987	.16997	.07248	.05012	.85955	.08219	.02229
V46	.09835	.18111	.00493	.04653	.03563	.85822	.01721	.16908
V29	.04407	-.01251	.04457	-.01716	.01377	.13069	.69738	.01858
V35	.12722	.08942	.09177	-.12492	-.04049	.15881	.59358	.20292
V6	.10729	.02929	.00691	.07826	.00373	-.04745	.53595	-.01716
V41	.08536	-.15901	.21302	-.08588	.04627	.07142	.52422	-.15506
V37	.12240	.06304	-.09415	.08924	.05845	.01307	.28268	.71377
V36	-.09868	-.00749	.16873	-.04019	-.06875	.12398	-.24343	.60596
V38	.00633	.04920	.03646	-.06407	-.03952	.04067	.00041	.59615
V40	-.12468	.01787	-.03449	.05142	-.09865	.02869	.05418	.02225
V42	-.11236	.10152	.03524	-.14115	.04055	-.00150	.04491	-.02221
V19	.12859	.01305	-.01253	.13566	-.02372	.13753	.03900	-.09864
V23	-.09279	.20752	.03215	-.08674	.10382	.10812	.01966	.09253
V28	.37057	.16902	.14079	-.17749	.03454	.04045	.12085	.13921

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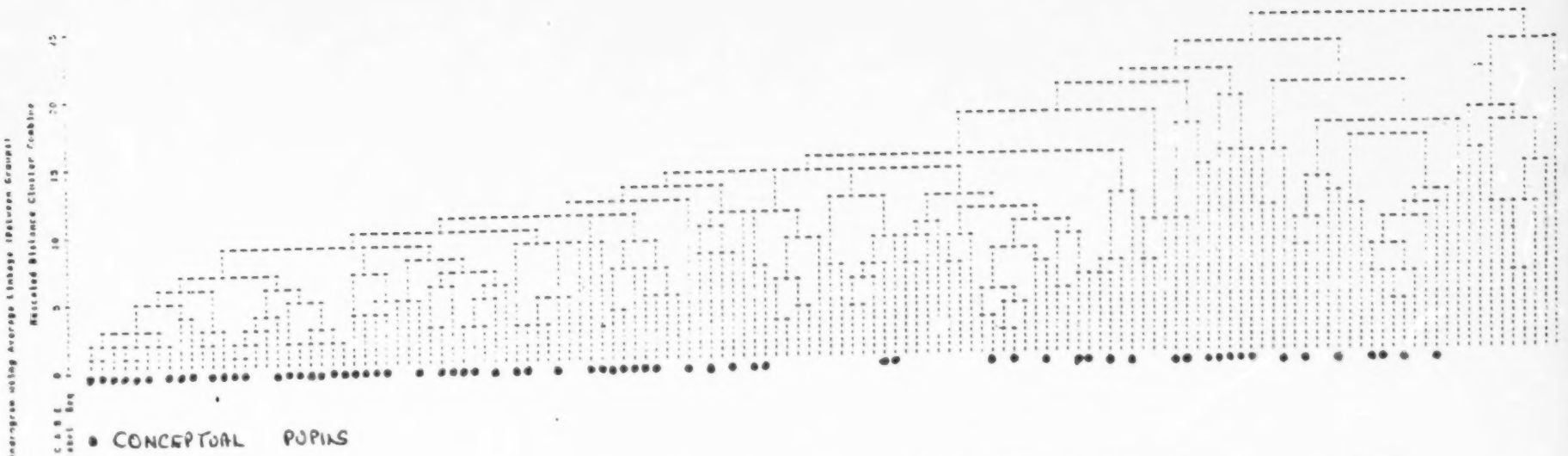

• CONCEPTUAL PUPILS

FIG. 20 CLUSTER ANALYSIS: CLUSTERING of BOTH TRAINING GROUPS BASED ON TEST SCORES.

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8.0 Discussion

The discussion of the results centres around two principal concept-systems of direction finding. These are orientation and bearings. Tests 1 and 2 are discussed together in that they both assess orientation skills; namely the ability to recognise whether a map is orientated and the ability to place a map in the correct orientation. Test 3 links this knowledge with map interpretation to identify location. These 3 tests are further linked in that the teaching programme was common to both the serial and conceptual children up to this point.

Tests 4, 5 and 6 investigated children's ability to estimate, measure and apply their knowledge of bearings with the children receiving either the serial or conceptual approaches. Test 6 was not part of the teaching programme but was devised to examine the transfer of learning to a novel but realistic situation in navigation.

Gender differences are discussed at the end of each section.

Both tests 1 and 2 showed a tendency for the serial group to perform better than the conceptual group though the success rate of both groups was very high. Given that both groups received the same instructional package this finding is difficult to explain. Perhaps the teaching of the serial approach is less time consuming than the conceptual approach and therefore more time was available for the practice of skill. The high success rate overall indicates the potential of children to master the skill of orientation. It suggests that the matching of the red north seeking needle to the enhanced, red, magnetic north lines is a useful pedagogical strategy for teaching basic orientation.

Test 3 built upon this skill of orientation and applied it to a locational exercise in the terrain. The task was dependent not only on the map being aligned with the compass to magnetic north but also on the ability to interpret the map symbols and relate them to the actual terrain. Since the features in the terrain were identical and in a symmetrical, or regular formation, the actual task posed considerable difficulty in its abstraction. There was no significant difference between the serial and conceptual groups and a wide spread of scores was apparent. The children could orientate the map and identify the features but there is evidence that the complex abstraction of the task of map interpretation caused difficulty. One is faced with similar situations in orienteering, but these would be considered advanced problems. It is highly unlikely that an orienteer would have to identify one feature from six

identical ones. Nonetheless the three tests overall indicate that teaching orientation with the compass must be conducted in relation to actual terrain situations and not as an isolated skill.

The difficulty in relating the terrain to the map when correctly orientated is something which will require further investigation. Although this posed problems for the children, it is suggested that the test itself has value as a screening test in orienteering training programmes.

There was a significant difference in the performance of boys and girls on test 1. Hesitancy and slight anxiety were noted when girls approached the test item. However, as confidence grew with familiarisation with the tasks the gender difference disappeared.

The investigation of bearings marks the point where the two contrasting learning approaches were introduced. The three tests involving the estimation, measurement and application of bearings showed strongly significant differences between the groups with the conceptual group, as predicted, performing better.

Test four examined the estimation and measurement of a bearing in the terrain, as a precursor to test six. The conceptual group performed better. However, the question must be asked as to whether children need to possess the ability to estimate and to establish the direction of travel as a numerical bearing when orienteering, rather than using the compass to indicate a direction which is not expressed in precise terms. It is argued here that children with a conceptual base gain by using the numerical reading as a checking device, receiving positive feedback to support their decision-making. It is also useful to know and use the numerical bearing when practising travelling on bearings, establishing the direction of features and when mapping the position of objects. If one considers navigation using an Ordnance Survey map, rather than an orienteering map, then adjustments to the bearings have to be made between grid north and magnetic north which involve numerical calculations. Finally the value of this particular activity is seen as a building block for later, more complex, navigational activities and was revealed by an analysis of the competencies which one is required to possess in order to complete the task of taking and travelling on bearings. It is argued that the teacher/coach should be informed of the value of this analysis in order to identify children's competencies and to make decisions as to how to develop them or provide preliminary, or remedial treatment.

Test 5, involved using a simplified map in an abstract setting. However it did test the skills of taking a bearing from the map and applying that bearing to the terrain. Again there was a significant difference between the groups with the conceptual group performing better. This result is supported by an analysis of video recording of the activity. The video analysis reveals that the serial approach breaks down because of a failure to carry out the steps correctly or due to confusion between the elements involved such as lining up arrows and needles, rotating the housing and reversing the direction of travel arrow. It would appear that when the learning breaks down children who do not have a conceptual basis fail to recognise the errors or are unable to rectify them.

Analysis of errors on test five shows that more are made in the sector of bearings between 100 and 260 degrees though there is no ready explanation as to why this should be so.

Test six, the concluding and novel test, has direct relevance to orienteering at all levels. Courses for young children tend to follow linear features and on reaching the junction of several features two basic questions might occur. First, the child might ask "Which way do I go now?" "The second might be preliminary to the above and involves the checking of location. "If I'm <u>here</u>, then that path should be <u>there</u>." It is important to be armed with skills enabling correct action at decision making points; to possess understanding which allows decisions to be checked; and to have confidence in the decision taken to produce the answer. Again, there was a significant difference between the groups with the conceptual group performing better.

There were no differences in the performances of boys and girls on tests 4 and 5 but there was a tendency for boys to perform better than girls on test six. This is an intriguing finding which does not yield to the kind of explanation put forward to account for the superiority of boys on Test 1. A more extensive investigation of boys' and girls' performance is desirable.

The sum up, when children are taught to measure, estimate, take and use a knowledge of bearings by a conceptual approach, which equips them with a concept of rotation from north and which can be articulated either as cardinal points or as a precise numerical bearing, they perform significantly better than children who receive a serial, step by step learning approach. Further, than when the performance of boys and girls is compared across the two approaches differences are not evident except on one test which involves applied knowledge.

8.1 Implications and Recommendations

The research highlights orientation as a crucial skill in navigation. This skill is important at all levels of orienteering, and navigation, but it is particularly important to equip young children with confidence in orientation.

It would seem appropriate, therefore, to investigate how the concept of orientation develops in younger children and the teaching/coaching procedures required for them.

In addition four practical concerns arise from the conduct of the research which have implications for orientation at several levels. They do not arise from the test items considered but from the evaluation of the teaching programme, direct observation of the performance of the children and by video analysis of the tests.

First, it is suggested that map-makers reconsider the nature, size and colour of the magnetic north lines and arrows on orienteering maps in order to enhance the significance and use of these lines on maps for beginning orienteers.

Secondly, on beginners' courses and string courses consideration should be given to ways of providing guidance, or checking on the orientation of the map to aid decision making. For example, by indicating the position of north or by placing a correctly orientated map near to the control. Either or both should be positioned horizontally and clearly indicate the direction of north. If arrows are used care should be taken to avoid confusion with the direction of travel. The above suggestions are offered as checking devices which may enhance the decision making of young orienteers and raise confidence and the chances of success.

Thirdly, it is recommended that novices and young children use a compass which has minimal noise and which clearly indicates the direction of north. The research results demonstrate that the pupils can achieve considerable success in using the protractor compass but it is a complex instrument to use with the young. The teaching package for both the serial and conceptual groups utilised the map guide compass as a lead into compass activities and concepts prior to the introduction of the protractor compass. The map guide compass possesses minimal noise but it is used in a different way to the protractor compass in that it is clipped on to the map and cannot be used for precise bearing

work. It is recommended that consideration be given to the design of a protractor compass which possesses the simplicity and clarity of the map guide compass and which could be termed a starter compass. It may be possible to add on elements of the protractor compass so that the compass and user skills develop in parallel.

Fourthly, the task analysis shown in Figure 5 (p. 21) concentrates on the sub-elements of the concepts of a bearing and as such failed to reveal that the skill to take a bearing requires the child to understand the concept of parallelism. It is also necessary to possess this concept when using a compass to orientate the map. Both the base plate and the base of the rotatable compass housing possess parallel line markings.

The analysis undertaken and the instructional literature currently available fail to reveal this prerequisite in the learning.

What then is the future direction of this work? Initially, the task is now one of dissemination. Principally, the results will be directed at coaches. In November and December, 1990 four coaching conferences will be attended where the advantages of the conceptual teaching programme will be outlined. The audience will be male and female coaches at regional and national levels.

Secondly, the recommendation concerning the development of a starter compass will be pursued with the Swedish manufacturers, Silva Ltd.

Thirdly, it is intended to publish the teaching package for orienteering coaches and for educational purposes. The published material can be supported by video sequences and is seen to possess potential for geographical, mathematical, environmental and outdoor education. It is not just for young children but all novices involved in land navigation.

Dissemination will also take place with the Local Education Authority from which the sample was drawn and it is envisaged that the teachers will form a resource for the development of navigational skills in children within the authority.

The title of the project is most apt in that not only are the skills of navigation investigated but developmental aspects are pursued also. Given that the research has shown

the conceptual approach possesses advantages over the serial approach the research team needs to address the question as to whether the approach can be refined further or reconstructed in any way. Equally the project team will now need to reconsider the extent to which the research focus will be on the education of the coaches, or on how children develop their skills of orienteering. Of course, it may be possible to keep both foci in view.

This report has concentrated upon the empirical findings of compass use with young children. During the process of designing the teaching programme, inducing the teachers and working with and assessing the children, the research team has gathered evaluative material relating to the teachers' and children's attitudes towards compass use. We have not been able to review this material so far but it will be important to disseminate the reactions to the programmes in addition to the actual results of the tests.

9 Proposed progression of the project and aims for the second year

9.1 To disseminate the findings to orienteering coaches by presentations at regional and national conferences.

9.2 To disseminate the findings by the publication of sections of the report and by articles in international and national journals and magazines. These will include "The Scientific Journal of Orienteering," "Compass Sport," "British Orienteering Federation News" and "The Coaching Newsletter."

9.3 To publish the findings in articles concerned with navigation on land and to highlight in the educational literature the application of practical orienteering skills as they relate to the achievement of geographical and mathematical targets within the National Curriculum.

9.4 To refine and publish the teaching package for coaches and to provide support material in the form of a video presentation. This can take two forms, one exemplifying the teaching approach and the other presenting situations featuring children demonstrating the skills correctly and incorrectly. This material can be utilised in the teaching and assessment of coaches.

9.5 To develop a starter compass for young orienteers and to consider the development of compass design to support the teaching package.

9.6 To consider how support can be given via the map and materials in the terrain to the direction and orientation skills required by young and novice orienteers.

9.7 To examine the visual and audio evidence on the teachers' and children's attitudes to the teaching programme and to disseminate the findings.

9.8 To disseminate the findings related to gender identified in the research.

9.9 To extend the study of the development of orientation and compass work in the young and to investigate the abilities of younger children to learn skills used in orienteering.

10 - Relationship with the Governing Body

Throughout the year the relationship with the Director of Coaching, the Chairman of the Coaching Committee and the Coaches on the Steering Committee has been excellent. This has been evident via the support, encouragement and involvement in the design of the research and interest in the results. The Director of Coaching has enabled the dissemination of the results by building presentations into the 1990/91 Coaching Conferences and in the literature available to coaches and orienteers. The research team wishes to express its appreciation of the support of the Governing Body throughout its activities.

11 Current and foreseeable problems

The Steering Committee at the last meeting, 2 October, 1990, complimented the research team on the amount and quality of research conducted given that the project actually began in November, 1989. After this period of intensive fieldwork, it is clear that the team needs to disseminate the findings fully within the sport of orienteering, and to consider the wider implications for all those concerned with the teaching of navigational skills. At the same time the team is aware that further empirical work is necessary on the actual skills of orienteering and in pursuing developmental aspects with the young. The design and piloting of a compass specifically aimed at the beginner is common to both the skill and the developmental research areas.

This report has indicated several directions in which the research could go. Dissemination among and, reaction from, the coaches in orienteering will help in sharpening up possible future focus and direction. The research will also give practical support to coaches. The developmental strand however should not be overlooked as more immediate implications are pursued. Therefore the research is moving into a new phase of dissemination and application while sustaining a programme of more basic research in the development of skills. This has resource implications.

The research is conducted by a director (0.2), a part time research assistant (0.5) and a part time research secretary (0.3). The time commitment was geared to the grant available at the time of application. The research team now wish to ascertain the degree to which the grant can be extended to allow the team to devote more time to the research. Further, given a cost ceiling we would welcome discussion of the expectation of the funding body concerning the balance between dissemination and further empirical work in the second year of the project, given that the project has a further three years to run.

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